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WORKS ORGANISATION AND CONTROL.

Paper presented to the Institution, Preston Section, by L. C. Row, M.I.Mech.E.

General Considerations.

WORKS organisation and control is something which under innumerable titles has been carried out from time immemorial. This is proved from the historical records of the Egyptians, Romans, and Incas. The Pyramids, Rome, and Cuzco in Peru, provide the realisation that such colossal enterprises could never have been undertaken without a vast amount of "Planning as to 'ways and means' and systematic organisation," in carrying out the work.

There still exists among engineers and others the mistaken belief that the attainment of a high degree of efficiency in organisation means a large expenditure of money, a mass of paper work and a small army of people. The truth is that no business can afford to be without organised systems if ambitions and success are to be fully realised, but the cost need not be excessive in any way. In fact the simpler a system is the more workable and effective it should prove.

It is impossible to offer a specific solution of a problem that differs in almost every works, and varies as widely as the personalities of the employees. On the other hand it is possible to submit a number of principles which can be applied to any organisation, large or small, and ranging from mass production to general engineering. The key to efficiency throughout is a thorough "understanding of the principles involved," and "simplicity in application."

The foundation stone of commercial success is a really sound manufacturing policy: in fact without this backing neither organisation, administration, nor personal skill would be of avail. The combination of these principles and policy provides the strongest equipment for the investigation and solution of any problem.

The whole organisation of any industrial concern is centred round the product and the first and main application of a manufacturing policy is that of production efficiency. This may be defined as: The production of the necessary products at the required time, in the correct quality and at the right price. The manufacturing policy determines the standards of the product—time, price, in fact every standard, and the aim of production efficiency is the attain-

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ment of these standards, which calls for the greatest skill in technology and administration.

The most favourable conditions for the highest efficiency are mass production, or the continuity of individual processes or operations. The principles of repetition are similar in many ways but there are subtle differences between repetition and mass production which require very careful diagnosis and treatment to avoid serious pitfalls.

Mass production does not necessarily mean large organisations and works, but can just as well be attained in a small plant, as long as the principle of "continuity" is maintained. It is not uncommon to see a works where part is on mass production, and another section on batch or even single jobs, the essential conditions governing specialisation apply to the product, and everything in connection with it must be treated in the same way.

The works responsibilities and activities commence when the design has been approved, and is in a satisfactory state for production. These conditions may vary according to the class of product, quantity, and standards, but whatever these may be, for successful operation the closest co-operation is essential between the works and designs department.

The importance of friendly relationship between those two sections cannot be overestimated, and unfortunately is not too prevalent even now. It is often found that quite a small alteration to the component before release for production results in very big savings in manufacturing costs. There is another avenue of possible saving, which is very often neglected, namely, during the stages of experimental manufacture. One seldom hears of detailed reports being furnished by those carrying out this work, particularly in relation to difficulties experienced and small alterations made to make the article function correctly. In internal combustion engines and other parts of road vehicles it is sometimes found that whilst a unit has passed its tests successfully troubles arise in production and performance. What usually happens is that during the experimental stages, tolerances, clearances, etc., have been altered to make a satisfactory job, but are not recorded.

Before drawings and particulars are issued for production they should be passed to the production engineers for examination and recommendations for ease and efficiency in manufacture. To assist in this direction the designs department should be supplied with up-to-date particulars of standard tools and equipment, particularly such expensive equipment as broaches, hobs, form tools, etc. These particulars help considerably in reducing expense and delay in connection with new designs.

Composition of Organisation.

The organisation of an industrial concern is made up of a number of groups, which are divided into, and contain all the sections and departments of the factory, such as :—

Design.—In large establishments this group generally comes under the leadership of the chief engineer, and incorporates : Drawing office, research and experimental departments, metallurgy for experimental and new developments. The control of production materials for specification, and the heat treatment departments also come under this heading, but as a matter of routine.

Preparation for manufacture (*Production Engineering*).—Sections : Planning, jig and tool drawing office, rate-fixing tool room with its auxiliary services.

Material control and progress —Sections : Receipt and despatch, stores of all classes, material purchase and progress from outside sources, progress of materials in and during manufacture.

Manufacture.

Distribution.

Auxiliary services.—Control of sections, power plant, buildings, distribution services, plant upkeep excluding work done by tool room.

Works statistics.—Costs—production and establishment, wage analysis, etc.

Design.

It is here that the text of the contract is translated into terms of technology. The product may be entirely standard; partly so, or require a completely new design. Whatever the circumstances are, the final issue of instructions for the manufacture to the works should include : Drawings, particulars of the order in the necessary details, and the specifications of materials per unit. This unit specification consists of : Part number, description, quantity per unit, and class of material ; all of which are very essential for ease of control in the works. The importance of the part number however, extends far beyond the four walls of the factory, due to the ease of reference and record, and particularly after manufacture where the product is sent overseas. The quotation of a part number by a customer requiring replacement leaves no doubt as to what is required, whereas a description of the required article is apt to be misleading and expensive when ordered by cable.

Preparation for Manufacture.

The successful operation of this group provides the key to efficient and economical manufacture throughout, and may rightly be called the " hub " of the factory. All the departments under this

heading are very closely allied in their work, which covers the product from the issue of drawings and particulars up to and including manufacture. Their responsibilities include : (1) Analysis of product for efficient economical production; (2)pre-determination of methods of production and operation sequence ; (3) layout of plant to carry out the above methods and sequence ; (4) determination of machine tools, also the design and provision of the most efficient equipment to produce a given product in accordance with the manufacturing policy laid down ; (5) the operation of an efficient system for the collection and record of all necessary information for the correct functioning of the group, past, present, and future ; (6) the issue of all tools and equipment for production. (Maintenance is included under tool room section).

The consideration of new machinery and equipment. In connection with the replacement of plant and machinery, the following are points to be considered : (*a*) Excessive maintenance costs ; (*b*) existing equipment not capable of producing work to the required standards of quality or time ; (*c*) the purchase of new machinery, justified by the increased productive capacity ; (*d*) different class of machinery required due to change in design or manufacturing policy.

Recently there has been a definite tendency towards the use of a high production general purpose machine, capable of quick change over, and easy set up, as compared with the single purpose machine of greater producing capacity, but strictly limited in the variation of product and flexibility.

The consideration as to whether new machinery should be of the single or general purpose type is largely governed by the class of output, quantity per unit of time, and the possibility of sufficient savings being made before a change of manufacturing policy is likely to take place : (*e*) Cost of new machine ; (*f*) second-hand value of old machine ; (*g*) period (estimated) within which new equipment will pay for itself, after allowing for interest on capital expenditure.

The sections forming this group may be arranged in combination according to conditions existing, and this particularly applies to the planning and jig and tool design departments. The work of the two sections is very close, and follow each other as a matter of sequence.

As previously stated, part of the work of this group is the determination of methods and equipment for manufacture, and this information is generally conveyed to the manufacturing and other departments by means of the operation sheet. The details contained therein vary according to the needs and systems of the individual factory, but the following particulars are generally specified : Manufacturing or batch quantity ; sequence of operations and details of each as to the work to be carried out ; location of equipment to

carry out operation ; particulars of jigs, tools, and special equipment provided for the operation ; feeds, speeds, etc.

It is the custom of some firms to issue these operation sheets separate from the drawing, but it is suggested that this method is uneconomical and liable to confusion. The drawing and operation must of necessity be used together, therefore the latter should be part and parcel of the drawing, either by pasting the operation sheet on to the print, or providing a space on the drawing for this information. If this is done everybody concerned, including the operator, has all the information required at hand, and saves a considerable amount of time and expense : in addition there is one source of information only to which all must refer, thus saving extra floating copies which are apt to be mislaid, and consequently perhaps not kept up-to-date.

Machine Occupation Sheets.

It is well known that one of the keys to efficiency is the maximum time which plant and machinery are occupied in production.

The operation sheet indicates what machines are to deal with a component, but in the best regulated shops, however, there is the spectacle of machines standing for want of work, and it is here that the machine occupation sheet or card provides the solution to this problem in showing all jobs suitable for the machine. According to requirements the sheet can be made to contain just the jobs which are done on the machine, or on the other hand include such items as quantity per batch, time occupied, balance of time available. When a machine comes out of work reference to this card often provides repeat jobs on reference to the production office, thus keeping idle time down to a minimum.

Jigs and Fixtures.

The use of these parts of the equipment for manufacture is always a widely debated subject, but whatever opinions may be, there is no doubt they are essential to interchangeability. In addition their use is often justified by saving expense in rough and finished inspection. Simple jigs and fixtures can be made just as effective and useful on small and medium quantities, as their complicated brothers for mass production, and it is a case of logical analysis of their values according to the conditions prevailing.

It has been found a great advantage when considering new work on stamping, and often casting, to ask the suppliers to submit drawings of what they would supply, together with the accuracy obtainable. This information enables the production engineers to decide the various points of location with certainty. In the case of stampings, and where dies are used where there is a growth, a limit should be specified as to the increase in dimensions, this gives

the supplier the opportunity of watching his dies, and provides a source of semi-automatic inspection. The waste in industry due to excessive material is enormous, and is a matter which does not get the attention it deserves in all classes of materials. In the case of castings the foundry can be greatly assisted by the patterns being suitably marked for locating points, machine faces, etc.

Tool and Equipment Services.

The activities of this section fall into two categories: Production of equipment for manufacture and maintenance of existing equipment. Under the latter heading is the tool stores, and the efficient and economical control of tool stocks is a very important matter in cost. It is a fact that many firms do not know what financial expenditure is vested in tool stocks, and if a careful and truthful survey were taken, the results would not only be interesting but astounding. This excess is often due largely to the lack of a system of control of location of tools out in the shops, and the following is a system which has proved very efficient in dealing with this problem, and at the same time is simple.

Every tool has a check, and every operator has a standard number of tool checks in his possession. Let us take an example which will explain the system :—

There are, say, five taps, $\frac{5}{8}$ in. B.S.F. in stock, and a corresponding number of brass checks on the bin hook. When an operator calls for a tap he hands in his tool check, which bears his personal check number. This is placed on the bin hook, and the corresponding $\frac{5}{8}$ in. B.S.F. tap check is taken off the bin hook and placed on a separate operators' check board under the employee's number. If all the tools are out on issue and there is an additional call, the tool storekeeper goes to the tool bin and goes through the operators' checks, making inquiries as to whether the jobs are finished or not. Generally at least one tool is finished with, and the man has forgotten to return it, or arrangements can be made to supply the last demand without having to put into circulation additional tools. This system is also very valuable in checking the return of all tools to stores before an employee leaves : before a man is paid up he must present a tool clearance ticket, which is issued on demand by the tool stores : after all the man's personal checks have been accounted for, and the corresponding tool checks replaced on the tool bins with the return of the tools.

This system is not so complicated as it may sound, and the small amount of financial outlay is quickly repaid in the reduced quantity of tools in circulation, and the ease of location control.

Plant and Machinery Location.

This much debated subject falls under the group of " Preparation

for Manufacture " and the deciding point really rests with the degree of continuity of operations. If the continuity is sufficient, then the obvious location of all the necessary machinery and equipment is that of the sequent operations.

Rate Fixing.

There are many systems of piecework in operation, the merits of which would take too long to discuss this evening.

Material Control.

Generally speaking, materials represent the major portion of the prime cost, consequently the responsibilities of this group are serious, and the opportunities for economy frequent. Efficiency in material control does not only mean economical purchasing, which although showing considerable saving, does not provide as much scope for economy as efficient stock control. This is by no means easy, particularly where there is a varying demand, a good example of which is found in the supply and demand on service replacements for road vehicles, particularly of commercial type. In this business quick and efficient service is one of the keynotes to successful enterprise, and a high degree of efficiency in the organisation is necessary for satisfactory control, particularly when a model has gone out of production.

There are numerous methods of stores control, each one varying according to individual needs. There would appear to be many advantages in the system of stock ledgers, which provides a ready and simple means, financial and physical, of stocktaking at regular intervals, which is essential for economic control.

A very important matter in stock control is the question as to whether stocks should be kept in the raw or finished state. If the anticipated demand should not materialise then there is a large saving by holding the stock in the raw state as the excess of manufacture is avoided. It is obvious, however, that a certain amount of stock must be kept against immediate demands, and the most efficient control is met by a reasonable balance being kept in both states. This is controlled to a great extent by the manufacturing quantity for production, combined with the period required to put the batch through the shops and place into stock.

When there is repetition, the manufacturing or works orders are issued in accordance with the following policies :—

(*a*) Manufacture of articles to maximum and minimum stocks.
(*b*) Manufacture of components to pre-determined programmes.

The control of supplies as regards castings is fairly simple, but very great care is necessary when dealing with bar material, stampings and pressings. One has to consider very seriously the problems and troubles of the supplier. Even bars, stampings, and pressings

have their origin as a casting, but their state entails many further processes which entail both time and money.

The suppliers have a limit below which it does not pay them to put in rolls or set up dies, and in these days of special steels their difficulties are passed on to the man who casts the ingot, and a special cast has a minimum value also. It is essentially a case of supply and demand, and on investigation it is often found more economical to order this class of material if immediate requirements are small, to cover a period which has a reasonable demand on the supplier.

When ordering raw materials, if the quantity warrants, it is often an advantage to arrange for alternative sources of supply; this arrangement forms a competitive basis, and also prevents any break in continuity of supply.

Manufacturing or Works Orders and Progress.

These orders are recorded with other necessary particulars in some form of book, sometimes called works order routing book. Particulars of order number, batch quantity, balance of raw materials left, operation progress, scrap, rectification, and finally the balance in the finished stores are entered in it. The arrangements and range of these details vary according to conditions and requirements, and can be either simple or elaborate.

A quick method of reference to orders in progress and incomplete is very essential, and every job has an order number allocated, which is recorded consecutively in an order register book. This is a very good example of very important matters being executed in the simplest manner possible. It is well known how easy it is to have a large amount of materials and unfinished jobs lying about in a factory, probably forgotten in the hurry and bustle of concentration on more urgent matters. The index is made out in duplicate, and contains: Shop order number, part number, description, quantity, and date completed. This visible index shows immediately what jobs have not been finished, and provides the necessary handle for inquiry as to delay, and urge for completion. The duplicate copy also provides a very important link in the organisation between works orders issued and the production cost office; this enables the latter to keep a constant check on any delays in the particulars required, especially on labour and materials.

Distribution.

This group deals with the product from manufacture to completion of the contract, and as it only concerns the works in a minor degree it is not proposed to discuss this section at length. There are certain exceptions, however, where the works are directly concerned with distribution, in such products as large power plants, heavy works

equipment, etc. There is a vast amount of work in erection on site and these contingencies have to be provided for in many ways during manufacture.

Indirect Services.

All manufacturing establishments are divided into two sections especially as regards personnel and their work, they are : Direct and indirect productive units. One often hears the term " non-producer " used, which it is suggested is neither a true nor just statement, and often causes misunderstanding and sometimes unpleasant feeling. Whatever position a person holds in any organisation he must essentially be an aid to production, as all activities are centred in it. Therefore, as stated previously, the sections coming under this heading are those who are concerned indirectly with production, and include office and works staff, supervision, inspection, tool room, and all plant services, etc.

Inspection.

A description of this title would be " Control of Quality," in all matters excepting that of metallurgy.

The maximum efficiency may be termed " happy medium ," as inspection can easily be under or over-done, and both are equally expensive, the former in faulty products, and the latter in excessive costs for the amount of control required. Many manufacturers consider this department has a retarding effect on production, but there is a very true saying " when quality is controlled, quantity takes care of itself."

For interchangeability in manufacture it is essential that limits and tolerances should be shown on a drawing, as they provide the degree of accuracy to which production must work, and ease of control by inspection, by eliminating any matter of argument and personal opinions between the operator and inspector. There is always a debatable point where limits are not shown as to what degree of accuracy is necessary, in that there is some latitude in the dimension given ; in order to surmount this difficulty one works have a rule that unlimited dimensions shall have a tolerance of X .010", whilst this is not essentially the correct figure for all classes of engineering products, it is very necessary that some definite figure should be quoted.

Works Statistics.

This group includes such departments as : Costs departments—production and works expense ; wages departments—time-keeping, piecework calculations, employment.

One could easily spend a whole evening discussing this most important and interesting group, the activities of which are just

as important to success as any other section. In dealing with the productive costs, and also the works expense, but particularly the former, the main object is to have the information available as rapidly as possible, and this applies particularly to repetition and general work. The ideal state, of course, is to have the cost figures available up to the existing point in manufacture, and the nearest approach to this is attained by progressive costing, which may be carried out according to conditions by systems ranging from mechanised costing on such as the Powers and Holerith systems to the time clerk keeping a progressive total on the back of an old envelope. Many factory managements still fail to realise that an efficient costing system is one of their greatest aids in production. Work is planned out and arranged in the most efficient manner, but what organisation is there to show that the labour and material estimates have been exceeded ?—nothing but a system gives a warning before that state is reached—it is better to be sure than sorry. There are many factors governing the consideration of a cost system such as rate-fixing, time recording, inspection, etc., but they can all be adapted to provide the outstanding need—rapid costing.

Works Accounts or Establishment Costs and Charges.

In all manufacturing establishments there are two kinds of costs : Prime cost, which consists of productive labour and materials and factory cost, which consists of prime costs plus establishment costs ; on costs, or other terms.

It is evident that the collection, analysis, and control of these works expenses are vital to success. The point of highest efficiency in these expenditures depends upon the manufacturing policy and conditions prevailing, and what would be quite a moderate figure in one factory would be almost outrageous in another. Whatever the circumstances may be it is suggested that the soundest policy is to manufacture a product of outstanding quality at a little higher productive cost. Every effort should be made to obtain low on-costs, the advantage of which spreads throughout the factory in all its activities.

Here again it is not necessary to have an elaborate and expensive system, but rather one of simplicity and understanding. Unfortunately there is not time to deal with this matter as fully as one would wish. The main basis for dealing with indirect charges is the classification of all expenses coming under this heading, and a simple reference code for all details of these classifications, which enables them to be collected and specified departmentally as well as in total.

On reference to the chart showing " classification for expense " it will be seen that almost every detail has been provided for, and

is analysed in processes and departments. This chart is chiefly for office use in the final allocation of accounts, but for works use the combination of standing order and department number is all that is required. Taking an example, it is desired to ascertain the amount of idle time due to waiting for work, in total and departmentally. Referring to the list of standing orders, it will be seen that 111 is the order number of this expense; to this in every case must be added the department number, say, machine shop, No. 1, this would therefore read 111/1. To obtain the total it is only necessary to add up all the expenses coming under the number 111.

It would be impossible in works control to investigate weekly all the details of this system. Therefore, they are made up into a final summary which shows at a glance all expenses by departments throughout the works, and gives sufficient information to enable inquiries to be made where necessary.

EXPENSE ORDERS

No.	Description.
101	Supervision by chargehands.
102	Inspection.
103	Foreman, shop clerks, and works staff.
104	Labouring.
105	Apprentices attending school, holiday pay, and shop stewards attending meetings.
106	Engineer apprentices' tuition.
107	Heat treatment.
108	Gatemen and watchmen.
109	Storekeeping.
110	Boilers.
111	Idle time (waiting work).
112M	Idle time (m/c. breakdown).
112B	Idle time (belt breakdown).
112T	Idle time (tool breakdown).
113	Delivering customers' vehicles.
114	Furnacemen (H.Q. and Farington only).
115	Works and staff transport.

REPAIRS AND RENEWALS

150	R. and R. to machines.
151	R. and R. to standard shop tools.
152	R. and R. to jigs, templates, gauges, and special tools.
153	R. and R. to patterns.
154	Reparing and sharpening saws and cutters.
155	R. and R. of belting.
156	R. and R. to land and buildings.
157	R. and R. to plant.
158	R. and R. of motive power and gearing.
159	R. and R. of services.
160	R. and R. of electrical installation.
161	R. and R. of trade fixtures and utensils.
162	R. and R. of office furniture.
163	R. and R. of works and staff transport.

LIST OF DEPARTMENT NUMBERS IN CONNECTION WITH THE EXPENSE ORDER NUMBERS GIVEN ON THE PREVIOUS PAGE.

Dept. No.	Description.	Dept. No.	Description.
1	Machine shop.	15	Electricians.
2	Inspection.	16	Finished Stores.
3	Tool room.	16B	Spares stores.
3A	Tool stores.	16C	Rough stores.
5	Blacksmiths.	17	General offices.
5A	Heat treatment.	17A	Works offices.
6	Canteen.	18	Sandblast.
7	Frame shop.	19	Receiving and despatch.
8	Fire engine.	20	Power plant (electrical).
9	Tinsmiths.	20A	Power plant (steam).
10	Body shop.	21	Transport.
10A	Wood machinists.	22	Ambulance room.
10C	Joiners.	23	Demonstration fire engine.
11	Paint shop.	24	General.
12	Repair shop.	25	Leyland.
12A	Service machine shop.	26	Farington.
13	Patternmakers.	26A	Farington power house.
14	Millwrights.	27	Kingston.
14A	Yard gange.	28	Liverpool.

Example of booking time to expense orders by departments: Labouring in machine shop would be booked to order No. 104/1.

The number 104 indicates the classification of the work to be performed, and the stroke 1 the separate account to which the cost is to be charged i.e. Machine Shop.

Investigation and Reorganisation.

Works organisation in a new business is comparatively easy, in that a new start is being made without many existing handicaps, and advantage can be taken of all the latest developments and resources. These conditions, however, are in the minority, and the general case is that of the investigation and reorganisation of existing plants and systems, a matter which is difficult, and one which requires, in addition to ability, a big reserve of tact and patience.

We have already discussed the functions and activities of the many groups and sections of which an organisation is composed, and it is essential to find out what they are doing and how they are working before any trace of reconstruction can be undertaken. Undoubtedly one of the simplest and most effective ways of recording the findings of the investigation is by means of progress of flow charts, portraying the flow of the product from the designs department to manufacture. These charts can be made up very simply and efficiently for any subject, or section of the organisation, such as tools and equipment, etc.

It will be realised that once having the facts clearly portrayed, the analysis is comparatively straightforward, and the effect of reorganisation and inter-relationship of the many problems can be visualised at once. A very simple method of keeping in touch with matters is to have a separate folder for each division, and file therein the chart, together with samples of all the cards, forms, etc., which are used. It is a most interesting hobby when one has a few minutes to spare, to take out a file, and set everything out in order and no matter how long the system has been in operation or how many times it has been examined, it is amazing the number of new and justifiable questions which arise.

Apprenticeship and Training.

It will be obvious that industry cannot continue to function efficiently without the regular supply of trained engineers and craftsmen, consequently a thorough and efficient system of training is a paramount importance.

There are two main divisions of students: (*a*) The youth who commences his career in industry by undertaking a term of apprenticeship, generally coupled with a course of evening classes; (*b*) a course of study covering a number of years at a university or technical college.

It naturally follows that the apprentice obtains more practical training than the student, but less technical knowledge, and the problem is to find a proper balance or combination of the two classes of training.

There is a considerable diversity of opinion as to the merits of the two systems, and it is suggested that the correct decision lies in the personality and outlook of the individual. In the case of a university or technical college training, when the student has finished his course there is often great difficulty in providing the link or application of his knowledge to the practical everyday industrial life, and the student's tendency, in spite of highly technical training, is to steer his course towards the commercial side of industry; on the other hand, the apprentice generally prefers to guide his career to the practical activities. There appears to be a necessity for both during and throughout the period of training for apprentices and students. Such a system is in operation in Scotland, and has proved very successful; it provides a period of about six months at college, then the same period in the works, repeating each year.

In works apprenticeship there is a very important and often neglected matter of placing students in the class of work they desire, and if figures could be obtained, the amount of waste would be astounding, through putting a square peg in a round hole. A system which although it may sound unbusinesslike has proved very successful is that of ascertaining the boy's interests and desires during apprenticeship. The majority of boys want to be engineers at some time; during their school term, and on leaving, they have an ardent desire to join this industry, coupled with vague ideas of wheels, connecting rods, and things going round, and it is only gradually that he realises the vast magnitude of this industry, forming his own ideas and opinions in unison.

A boy's first year is generally spent in finding his feet, but when he reaches eighteen or nineteen he should have formed a definite idea as to what line he would like to take for his future career. When questioned by a works official as to his desire for the future he is generally nervous and ill at ease, and consequently the truth is often missed. There is one place, however, where he is perfectly natural—his home, and he will open his heart and tell his parents things which he would not repeat outside.

This difficulty is overcome by a questionnaire in the form of a friendly letter being sent to his parents, asking for the desired information and it is seldom unsuccessful in good results, as the parents have a natural pride in their boy, and appreciate the evidence of interest shown by the firm where he is being trained. Thus the

small amount of trouble, and a 1½d. stamp generally brings happiness and often a successful career on the one side and mutual advantage to both.

Labour.

This is a matter so variable in every district, and one might almost say town, that it is impossible to say much. There are one or two matters relating to labour conditions internally which may be of interest.

Where men are working turns about they generally change weekly, and there is a big expense incurred by each one picking up the job ; this applies particularly in shops which are on miscellaneous work and not on long runs with permanent set up. One can safely estimate a half-hour per man per change over, which with on-costs added, amounts to a formidable sum of money in a year. To overcome this it is suggested that a cycle of four working weeks should replace the alternate, thereby incurring one loss in change over instead of four.

When working a double shift, it has been found advantageous to do this from 6-0 a.m. to 2-0 p.m. and 2-0 p.m. to 10-0 p.m. There is no advantage in the rates of pay of a man so working, but it enables the normal supervision staff to control both shifts. The early turn has only two hours to the start of the normal day work and at 2-0 p.m. the two shifts meet personally, when a very few minutes' chat enables the second man to carry on with very little delay. He also has the advantage of the same foreman until ordinary stopping time, when he should have obtained working instructions to enable him to carry on without trouble.

Talent and Temperament.

There are always two sides to any question, and works organisation and control is no exception. The subject may be summed up in the term " The successful combination of talent and temperament," the former being an easy problem compared with the latter. The subject of " human element " is one which cannot be learnt from any text book, but only from individual and personal contact, and study, and is one of constant necessity throughout business life. There is everyday evidence of perfect organisation and system being inefficiently and wrongly operated through the lack of understanding of " human nature," particularly by those in control.

Many members of management consider it a " loss of dignity " to confer and co-operate with members of their organisation, whereas if the truth were only realised, it is only by wise leadership and personal touch and understanding that any undertaking can be successful.

From experience it has been found that when considering any problem, the best results are always obtained by giving all the persons concerned an opportunity of studying the subject, and passing comment before the final decision is arrived at. The very fact of letting them have their " finger in the pie " spells success, as all faults are discussed and corrected before operation by the people who have to carry them out.

The successful organisation and control of any business is just like a good football team, in which the captain is playing, not always taking the ball himself, but feeding and passing to each and all of his men as the opportunity arises.

Discussion.

MR. SPURRIER: The type of organisation that Mr. Row has outlined to-night is one with which both he and I are familiar, and refers, possibly, more to the class of business in which we are engaged than perhaps the class of business which other members here to-night have to deal with. There are many different problems in works organisation, and I should say that possibly the most difficult type of organisation to deal with is the one that calls for reasonably large batches to be programmed and dealt with and at the same time calls for allowances to be made for considerable variations from standard. With that type of problem one must have a very flexible organisation, since, if it is not flexible, there is no doubt that the organisation as laid out in the first case becomes useless.

I have seen many types of production methods; there are, I think, three or four classes. In engineering, perhaps the most easy to deal with, as Mr. Row explained, is the straight mass production problem, whereby an article is laid out for manufacture. Discounting sales (which is always part of an organisation but which, so far as the works is concerned, must be discounted from the point of view of production), the mass production factory can be laid out to produce a certain article in certain quantities and, in my opinion, is possibly the easiest problem to deal with.

There is also repetition work, which may be a form of mass production, perhaps on a smaller scale. At the other end of the scale you get general engineering, in which there is practically no mass production; there again the problem is very different to the first two and perhaps not the one that Mr. Row has outlined to-night.

One of the most difficult problems to contend with in any engineering firm is the question of modification to design. When a programme is set and the type of article to be made is known, works problems are increased ten-fold when the designers or the engineering department decide to make modifications, either as a result of faults that have been found in the article or as a result of complaints from the sales department that the type of article being produced is not the one they wish to sell. That, possibly, for the management, is the most difficult thing to control in any works organisation, and I feel that in the majority of engineering firms a tight enough hand is not kept on the question of design during any working year. The question of modification to design not only affects the control of material that is required for production, but also affects to a very large extent the type of plant that one feels inclined to install in any factory.

We all know that design has to be altered and is being altered continually and in the mass production factory consideration has

to be given very carefully as to the type of machine tools and equipment which are to be purchased for the production of that particular article, bearing in mind the fact that, possibly in a year or less, that article may have to be changed.

I have seen myself many mass production factories in America. I was over there recently and found generally that in the automobile industries particularly, manufacturers were purchasing and installing more general purpose machine tools than perhaps they were ten years ago. They have found that the special purpose machine tools were expensive and not so versatile and easily changed over as the general purpose machine tools, and I think that throughout the world now the general purpose machine tool is, to a large extent, taking the place of the single purpose machine tool.

MR. CLAYTON: I quite agree with the lecturer on the question of experimental work as regards new models. I think experimental departments ought to have sufficient time to thoroughly test out any new models, so that when these models are issued into the shops for production, the minimum amount of alteration is necessary which, as our chairman has stated, is always very costly in material and time.

I was very interested in the question of the flow of production through different departments. There is, I think, one very vital point that has been missed. Flow of production is of very little use unless you have balanced operation. Without balanced operation you are going to have stagnation of some machines. You may save a certain amount of modifying of parts, but after all is said and done, balanced operation must be part and parcel of flow production.

I was rather surprised when he mentioned that operation sheets should be part and parcel of the drawings. If we had to start on those lines, I am thinking that everything would have to be duplicated, and what is the drawing going to look like? There might be 20 or 30 alterations. It is going to be a colossal thing. I do think that drawings ought to be kept for the purpose for which they are intended, that is, to show the finished article and the sizes and limits they have got to be worked to, and for no other purpose at all. That is a question for the shops and not a question for the drawing office.

We are gradually in this country coming to mass production, even in small industries. In the automobile industry in the last ten years, we have got into the foreign market due, absolutely, to mass production. Both in controlling and handling the machines one sees now the tendency to group together to cut out the small manufacturer and get the monopoly, and use that monopoly only in order to get mass production and a cheaper article, in order that we can compete with the foreigner.

MR. WESTALL: I am rather surprised to hear our lecturer, also our chairman, say that single purpose machines are giving place to more general purpose machines. I would say that as trade is improving and as, some few years ago, single purpose machines were quite common, I should have thought that under present conditions single purpose, and special purpose machines, would play a bigger part. There is no doubt that our production costs are reduced by single purpose and special purpose machines. Further, the quality of work from the machines, I believe, is better, generally speaking, than from the general purpose machine.

With regard to machine idle time, it does not matter which shop you go into, there is quite a number of machines idle. In the shop that is on mass production, or where piece work is in operation, I would say it is quite possible to estimate fairly accurately the amount of idle time of the machine. I would like to ask how would the lecturer estimate idle time in a works engaged on general engineering, where the class of work varies considerably? In a case like that we must have surplus machines and the machine efficiency must necessarily be very low.

With regard to co-operation between the drawing office and the experimental department, that is certainly essential. When a job goes into the experimental department—say there are some slight alterations—if these alterations are not recorded on the drawings, when those drawings go into the production shop, very often there is quite a deal of trouble caused.

With regard to control of quality, one firm I was with had a periodical inspection of gauges. The periods varied with the type of gauge and the amount of use made of them. In some cases they were called in every fortnight, in other cases every month or so. We all know that where this inspection of gauges does not take place, at some time or other we have trouble through parts not being assembled correctly. Parts go through the machine shop down to the assembly or fitting shops and they do not fit together. There is trouble between the people concerned in each section. If this very important item were attended to, it would certainly save a good deal of trouble.

MR. WILCOCK: I wonder what is the experience generally amongst production engineers with regard to the attitude of the various designs departments and the various engineering establishments as to what serious notice they take of standard equipment that is already in use. I must confess that up to now my experience has been that average designer tries to make out as many differences in design to standard tooling as he possibly can. He can have an 8-spline broach; he might have an 8-spline $^{5}/_{16}$, and he will know that these are in existence, and the next thing we will get a $^{9}/_{32}$'s 8-spline broach and so on.

See what happens with hobs and reamers. You can have $^{8}/_{10}$ pitch hobs or 6 D.P. heads and they will change one or the other for an 8 or a 10. I just wondered what the lecturer's experience was in that direction ? I should also like to know what your opinions are with regard to machines standing idle. I realise that machines standing idle or a collection of work standing in front of one machine is more or less controlled by the policy of the company concerned, but I do think that large quantities or large amounts of work standing against a machine is almost as bad, if not worse, than having machinery standing idle waiting for work to come to it. In the latter case it speaks well for speedy service and quick manufacture of the components concerned.

You raised the point during your lecture, Mr. Row, with reference to jig and tool design. This again is somewhat controlled by the type of component and the quantity which you are setting out to manufacture, but even in the very large production shops there are very many jigs which can be made of a very simple design and I think that these jigs can be manufactured and controlled under a very simple system. I also readily agree that there is the necessity for the complicated type of jig. If there are any designers present, I do not want them to get it into their heads that I have got a bee in my bonnet with reference to designers, but I do think the jig and tool man of to-day is beginning to suffer from the same disease as his brother and he tends to over-elaborate when it is not necessary.

Then there is the question of control of component stores. I notice you placed a card on the screen with a red dot on the back of it and all the information on the front of it to tell you when you have reached minimum or maximum, then you turn the card over and the red dot appears. A point strikes me there. The moment that the storekeeper turns the card over and the red dot appears, the human element enters in. What steps do you take to ensure that the individual who exhibits the red dot on the back of the card takes the necesary steps to see that the people who are responsible get a move on to placing that card the other way round ? I would make a suggestion for what it is worth. Would it not be a good thing if the foreman of, say, the building section had some say in the matter, i.e., the foreman responsible for building gearboxes or gearbox component spares was held to some degree responsible to see that the information conveyed by that red dot was carried to its proper place and very quickly.

I was very pleased to hear our President mention the modification question. The question of modification to an existing component is a very serious matter indeed and it does certainly call for serious consideration before alteration to an existing component takes place. We all know the trouble it causes us, not only in gauges

and tools, but the modification to machine tools and the general upset it causes to the operators as a whole. In other words, a very slight modification indeed to some of the larger components can very easily put a whole section out of step for a matter of some few weeks. I also agreed to a large extent with our President's comments with reference to the connection between the experimental and the designs department. It appears to me that the experimental department, as such, appears to confine their labours more to the component itself, as to its capabilities of performing the work for which it has been designed. There is the other side to it, that I believe Mr. Westall raised, and that is the question of errors or difficulties and problems in manufacture. I think it is as equally important that the " snags," as we call them, and the problems in producing those components in the experimental stage, should be noted and acted upon, and then it will save the production people quite a lot of unnecessary work and labour.

Mr. Row : Mr. Clayton was the first. He took up the question of balanced operation. To balance operation you have to time your unit and also plus-up where the operation time is more, and you might have two machines on one operation and one on another, to balance out. That is, as far as I know, the way they do in the straight mass production factories. They balance up by " plus-ing " or " minus-ing " according to the number of machines and the amount of time taken for the number of units they are going to produce. On the other hand, Mr. Clayton, you might not get an exact multiple. What are you going to do with the rest of the time left ? Leave the machine idle until its time comes round again or do some other work on it ? That I suggest is a matter of policy, whether it pays to do so or not.

Well, as a matter of fact, I purposely brought this up for an argument, but it is my contention that the operation sheet should be pasted on the back of the drawing, for this reason : An operator, if he is on continuous work on one machine, knows the job, but where there is any possibility of the labour being varied on that job or any change over, what is there to tell the operator what to do ? I suggest, that there is nothing except the operation sheet on the drawing. If you refer to a drawing in the shops, in 99 cases out of a 100 you have to refer to the operation sheet. When you have got to chase round after you have got the drawing to look at the sheets, there is time lost and it certainly does not make for efficiency.

The next point is that there only needs to be two, or at the outside three, copies of the operation sheet, whereas in one firm I know there are eight in circulation at the moment ; therefore, if a modification takes place, you have all eight copies to alter. The person altering them might miss one and then the trouble commences. It is my contention that there is no need to obliterate the drawing,

because if the alteration sheet requires to be altered, you can alter it on the back of the drawing just as well as in the book and if a new sheet has to be issued, it can be pasted on top of the old one and you are just in the same position as before.

Mass production is a very debatable question, but there is one section which believes that in many instances the small shop can get a job in and out before the big shop can get working. I think in certain circumstances this is so, particularly on small quantities.

Replying to Mr. Westall on single purpose versus general purpose machines, I suggest it all lies round the question of continuity of operation. If you have sufficient quantity to keep going on a single purpose machine, then I agree with you that probably it is the best policy to adopt, but at the same time, with a single purpose machine unless you are on absolute mass production—and very big mass production—it is a very difficult matter to keep that machine going. Then comes the question, is the saving in production more than your outlay in capital or interest on capital and depreciation and that I suggest, Mr. Westall, is the problem which arises, as to which is the best value.

Idle time, of course, is the bugbear of everybody. There is a system in existence whereby all idle time is recorded, but I can quite see your point, Mr. Westall, that you want to find out what the idle time is to be and, in a general shop, I cannot quite see how you are going to estimate it, because if the products which are coming forward cannot be forecasted, naturally you cannot forecast what is going to be put on the machine. If you have a certain amount of repetition work and you have a machine occupation card showing what you have done previously on that machine, it is quite possible that you may get a repetition job or start a follow-up system of showing where you can put a job to, by referring to that machine card. That only necessitates, if you are using a part number or description of what you have done before, running through the list, and you will probably pick out something which can be done within a reasonable period.

I think it is essential that alterations should be recorded on drawings down the side column, or some reference made to it on a bulletin or something which can be followed up for the alteration. It all depends on what the alteration is. In many instances it is better to issue a new drawing than just refer to what alteration has been made.

I suggest that periodical inspection of gauges is absolutely essential. There are two ways of dealing with it. One is, if you have continuous production—if the jigs and equipment are continuously out—that you withdraw the gauges at specified intervals for inspection. One firm I know withdraw their gauges on a Saturday; they are inspected and ready for Monday morning. On the other hand,

if you have a certain amount of repetition work but no continuous operation, I suggest a system be adopted whereby all gauges and tools are inspected when the job is finished and the jigs, tools, gauges, and equipment are returned to stores and inspected before they go into the stores so that you know when they are put into stores they are ready for issue again straight away without question.

On the question of the designers' attitude towards tools, broaches, etc., I agree with Mr. Wilcock entirely. I should like to ask Mr. Pilkington, if he is here, to reply to that.

As to machines standing idle, I quite agree with Mr. Wilcock again that is is just as bad, if not worse, to have too many jobs waiting for a machine than to have the machine lying idle. On the question of idle machines, I know that the Austin Co. prefer to have certain machines lying idle so many days a week rather than mix their jobs up and that, I think, is a point in connection with your question Mr. Westall. If a man finishes on a Friday morning, if he has done his quota, he can finish for the week. The Vauxhall people go even further and do that daily. When a man has finished his daily quota he can finish with full pay and I have seen men going home at 4-0 p.m. instead of 5-30 p.m.

I quite agree with Mr. Wilcock again on jigs being simple. I suggest that there again the whole basis of efficient control is a thorough understanding of the job and simplicity in application. In some shops we know that is is a general method to incorporate quite a lot of operations on one jig, whereas other people prefer to simplify their jig and split up the operations. Which of the two is the more economical and cheaper I am not going to say.

The red dot on the stores card is only an indication and it is up to the system which is in operation to see that it is carried out immediately. In the case of straight assembly, I agree with Mr. Wilcock that the assembly foreman should have a say in the matter and also take part in the chase to get things back to normal.

Modifications certainly are serious. As to the reasons of the modification, it is a very debatable point, but I do suggest again that there is not sufficient time allowed between the start of a new design and production. Take a car or a commercial vehicle. One can safely say that, really speaking,it should take nine months to thoroughly go into the matter, twelve working weeks for the design, twelve working weeks for development, and twelve working weeks for the preparation for production is certainly not too much and a lot of modifications, I suggest, could be avoided if sufficient time were given beforehand.

On the question of tools, I do agree. Take for instance the question of reamered holes. It is a bugbear to the shops to get a good reamered hole in some of the steels we use. In some cases we purchase broaches, which are a very expensive item. If another

size is brought out there may be very little difference in the dimensions, but quite sufficient to scrap the broaches, and, therefore, I agree with Mr. Wilcock that more use could be made of existing equipment.

Thorough investigation before commencing production is very essential in order to keep going. Before answering Mr. Wilcock's question I would like to call upon Mr. Pilkington to answer those questions on the subject of design versus works.

MR. PILKINGTON: As a result of the discussion to-night it appears that the principal point centres are the liaison between the designs and production departments. It is impossible in the course of an hour to go through this question of organisation in large establishments. It must be an elementary fact that time in design is of prior importance and in that time there must be definite collaboration between designer and production engineer to ensure that when the parts are in production they can go down the line and into service with as few changes as possible in the course of production. Design takes care not only of standardised production but departures from standard, and I venture to suggest that it is the departures from standard which cause the most trouble in the production department.

Reference has been made in the course of the discussion to the fact that sufficient attention does not appear to be paid by the designer to stocks of tools and parts in existence at the particular time a change is being considered. There may be very good reasons for this position arising, and it is not from the fact that the designer is not aware of the production position, but that that position is forced on him either by service or " political " demands. If a part is failing in service, then, if it is a matter of public safety, irrespective of what stocks or tools are in existence, a change must be made. Similarly, if for market reasons a certain part is not being sold, due—let us say—to a weight limitation, then it is perfectly obvious that it is of no value continuing to manufacture that particular part unless it has so been modified as to meet market requirements.

Summarising, I would say that machinery is in existence in any well-organised works for full collaboration to take effect, by means of the usual meetings where policy or changes are discussed and where decisions are effected concerning the production of any particular unit, and it would appear that the sole reason why full use is not made of this organisation is the very stringent demands on time under present methods of manufacture. We do not want any waste of time in considering preliminary design, experimental work, and preliminary production, but if everything is rushed then it is quite obvious that some mistakes can be made which have a very grave bearing on the production position. That collaboration is definitely in effect in the company with which we are concerned, and it is my

candid opinion that if the various departmental heads would not consider their departments so water-tight as not to openly discuss their own problems with other departments, then those difficulties would not arise such as have been referred to at this meeting. I would thank your Chairman for his invitation to be present at the meeting to-night ; it is my first attendance at a meeting of this nature and I sincerely hope that members of the designs staff will be invited to attend in future, as a means of further extending this collaboration which has been referred to so fully to-night.

MR. MARKLAND : I have listened with very great interest to the lecture and also to the subsequent discussion and now that the reds and whites have fought themselves to a draw, I would like to ask one or two little innocent questions on the lecture itself. My knowledge of works organisation is a very elementary one, not being connected with that particular branch, but I have always assumed that any works system, whilst important, must be simple ; in other words, the staff must run the system and not the system run the staff. Now the lecturer confirmed that subsequently with slides of as complicated a nature as I have ever seen. Furthermore it seemed to me that the number of processes through which a little simple elementary drawing had to pass before manufacture could be commenced, would account in many cases for the delays which are experienced.

The next thing is, that in works organisation I hold the view that the control office is a most important department. The lecturer has completely excluded the control office and I believe has failed to make mention of it. Whilst the planning and the jigging are also vitally important, we depend on the control office to see that the flow of work is balanced, therefore with an efficient control office it is my contention that many of the little difficulties which speakers who have contributed to the discussion mentioned would not arise and I seriously think that more importance should be attached to this department.

The next point is that the manufacture of quantities or even small batches of stuff is a relatively simple matter with an efficient control office and a decent plant and personnel, but there arises in all organisations the necessity for manufacturing non-standard parts. How should these parts be handled ? I should like the lecturer's opinion on whether they should be flowed in with the ordinary routine production or whether the ordinary rouutine production should be kept on a constant level and all special parts manufactured in a department or a factory specially set aside for the purpose. In my view the second suggestion has much to recommend it, in that the works system for that department could be simplified and the normal routine would not suffer in any way, yet by having this department prompt attention could be given to

those out of standard parts which, in any engineering organisation, must cause considerable trouble.

The next point is in connection with the stock cards. There is a very simple point there. The lecturer showed us a stock card and I noticed that at the top of it he put the maximum and minimum stock. Whilst I only just managed to see the slides I noticed that the minimum, which should have been 100 was allowed to get as low as 39 and that the maximum stock, which should have been 200 was allowed to get up to 300. Now I argue in all seriousness, where is the use in having that stock card if it does not work ?

MR. ROW : First of all, I should like to reply to Mr. Pilkington and pour oil on troubled waters, because on the one hand we have voiced our opinions, but I am going to say quite candidly that it is a marvel to me how Mr. Pilkington and his section get through at all. I only have the faintest idea of the amount of work he does, but it is collossal to me. I am not sure if it is not a case of the customer being the culprit, but the customer is always right, so the matter must drop.

" The staff must run the system and not the system run the staff " —I must agree. The slides are not really complicated and, further, if one investigated the amount of work which had to be done prior to manufacture and, just in the same way, if one analysed the amount of work which has to be done from the time the customer's order is received to the time it is issued to the shops, it is really colossal. It is difficult to assess the amount of work there is, and particularly on the debatable question of " modifications." When all the organisation has to be gone through for some point which, to the customer appears to be a minor point, it grows from a molehill to a mountain in the amount of work it has to go through and, in a great many cases, the expense that is incurred to attain that end.

I quite agree with Mr. Markland that the control office is a very important section, in fact, it is just as important as any other section. The flow of work has to be balanced, naturally, and it is here that the answer comes to many of the questions to-night

Generally speaking the control office is divided into one or two separate departments. The first deals with the raw material from the time the order is placed and the second from the time that the materials arrive in the factory to the time they are in the finished stores. We all know what a difficult matter it is to-day to obtain raw materials in anything like reasonable time at all. Also the question of putting alterations through the shops is a very difficult matter, because to many of us there is one point which stands out and that is that nearly everything is " first priority " and it is very difficult to keep things running anything like smoothly.

Small quantities with simple control. I agree with Mr. Markland entirely that there should be a separate department. If you are

going on straight production, get the shops going on that production and divert all your variables.

One of the biggest difficulties regarding stocks is the question of the period between the minimum being reached and the time necessary to put another batch through manufacture. We all know of many cases where we have got down to a minimum and stock has been completely out before we have been able to get further supplies through manufacture. Whilst the minimum and maximum stocks may appear to be rather unreasonable on the slide, it is an extremely difficult matter to settle any minimum and maximum stock which is reasonable right through a long period. It may be reasonable for a short period, but I doubt whether any maximum or minimum stocks carry for a long time.

MR. WESTALL : What system does the lecturer advocate for rate fixing, and what method does he advocate for payment by results, and why ?

MR. ROW : Mr. Westall has raised a subject which will take much more than a few minutes to reply to. My own personal opinion is that if it is possible to do the rate fixing in the office, that is the best place to do it. Make your first estimates in the office and then, if possible, have somebody to follow up any case for investigation, to see that things are running as the estimating office estimate. If there is any repetition, generally speaking the first time round may be found a try out, but in the case of a try out the tool room can help very often by watching the first time round and a lot of valuable data can be obtained from that.

There are so many systems of payment by results that is is difficult to suggest anything. Personally my own opinion is a straight forward plus bonus system with no frills on it, something that the men can understand and that is simple to carry out—is most effective both as regards the firm and the men.

MR. SPURRIER : If there are no further questions I would like to express a few of my own views on the questions that have been asked and the discussion in general. I am not going to take up much time, but it has brought one point clearly to me, and that is the fact that the production engineer's problem is not a problem at all provided he has not got to deal with modifications. I would say that the average production engineer would say to himself " Give me the article to manufacture, give me the quantity you require, and I will tell you the best way to do it." That, unhappily, from what we have heard to-night, is very seldom the case and, on the controversial subject of modifications, to my mind, there are three factors that enter closely into the method to be adopted. First of all the modification has to be decided upon by somebody. We will say, for example, that a modification is called for by the sales department—which does not come under the scope of the discussion to-night—

nevertheless, it is a modification that is required. I would consider that the right way to bring about the change in production as a result of this modification is to bring together the two sides directly connected with it, i.e., the engineering or designs side and the production or manufacturing side. The manufacturing side must be given definite notice of what is required of them in this modification and they must study their case very carefully before they come to the joint meeting. The engineering department on the other hand, will have their case prepared already, as to the reasons why this modification should be introduced. The production side has to consider first of all how soon they can introduce this modification and, perhaps secondly but equally important, what effect it is going to have on the occupation of their machinery. Modifications as a whole can upset machinery operation more than anything else and the works is laid out as a compromise in most cases to meet the demands for the class of article that particular firm is called upon to manufacture from time to time.

In my early remarks I referred to the class of machinery to deal with the production as tending to favour the universal machine tool rather than the specialised machine tool and I think these remarks are justified in the rapid change that is taking place in the various methods and types which are produced of any article to-day. When these two sides have met and discussed their points, it is then up to the management to decide whether such modification could be introduced at that time or whether it might be possible to leave it until a later date when the time is more opportune.

WHAT THE GRADUATE SHOULD KNOW.

Discussion, Birmingham and Yorkshire Sections, on paper by D. S. Anderson, Ph.D., B.Sc., M.I.Mech.E., M.I.A.E.

(NOTE.—*Dr. Anderson's earlier paper. "The Training of a Production Engineer," appeared in Vol.* XII, *P.* 178, *et seq.*)

Birmingham Section

MR. I. H. WRIGHT (Vice-President, in the Chair): The young people from various technical schools whom I have had to deal with appear to have covered a wide course but not to have really assimilated the instruction as well as they might have done. I suggest that graphic methods should be greatly extended. Unless the principles that the student learns in the evening schools and technical classes have a tangible existence to him he is apt to forget them, or think he understands them when he really does not, and the more graphic are the methods of illustrating the result of calculation, the more examples are worked out which involve bringing that principle into use, the better the chance of the student getting a tangible idea. Also, I think the hurry of school work and homework rather discounts the importance of checking. When you are doing responsible work and making calculations which are going to be embodied in expensive machines, then they have got to be right, and all calculations should be checked, preferably from another point of view.

When a student, after hearing a lecture and doing one or two simple calculations based on the lecture, takes down a few questions for homework, goes home and comes back with his efforts, the only thing that happens is that either he gets full marks or he does not —a very different thing from when he is calculating something involving a lot of money in an engineering construction.

I was glad Dr. Anderson impressed on us so strongly the question of three dimensions. It is of the greatest importance that if you are drawing even so simple a thing as a bearing ball, you should draw three views of it. They are all alike, but the principle is there. If you are drawing a pin, draw three views of it! The importance of having an actual three dimension conception of the thing is great. A large proportion of the troubles that arise in the shops are due, not to the conception of the draftsman who made the drawing being wrong, but to the fact that he has not carried out his three-dimen-

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sional idea, and certain of the detail has not been carried into all of the three views, so that when they get it in the shop, they have got two things in the same place, which is often rather awkward. To apply the three-dimension conception to everything you handle is of the greatest value.

Dr. Anderson spoke about the importance of measurement, and said that measurement is the limit of production accuracy. If you can produce things more accurately than you can measure them, you cannot tell how accurate they really are, because measurement is the limit, but I think, and I have been saying it now for over twenty years, that the micrometer has ruined craftsmen, to put it in a very bad way. The idea behind that is that in any machining operation the simple, direct, correct principle should first of all be conceived in three-dimensional form. That should then be developed in the parts that you are talking about.

There is, in my opinion, too much machining done now on incorrect principles of machining, and this is checked and accepted or rejected by measurement, whereas if the correctness of principles were the fundamental point, very little would require to be rejected. For instance, in grinding a cylinder, we all realise the principle that it must rotate on dead centres, while there are lots of other principles in other operations which are equally important which are often nowadays neglected. I suggest that the elementary principles of machining operations might be stressed more than they seem to be. It may be said that the people who are doing these faulty machining operations are not people who have been in the schools for many years, and it is quite possible, that what the students are learning now is more on the lines of what I want.

Mr. W. G. Groocock : I hope Dr. Anderson will excuse me if I do not offer any comment upon what he has said, other than to say that he has covered the ground so well that he has left us with little to discuss. I propose rather to go a little further and take the graduate at the point where he leaves technical instruction. The first thing that the graduate should know at that stage is that he is in exactly the same position as an artist who has a canvas in front of him on which has been roughed out a back ground for a picture. I want the graduate to know that the different educational authorities have given him his background, but that he must paint the picture himself. The educational authorities have given him directions how to paint that picture, but the final results depend on his own efforts.

I was very glad that Dr. Anderson showed us that first slide, and that he took for his objective the top of the three, that is, management in some form or other. This implies a considerable amount of study for the young man to paint the picture. He will, in the course of the painting, never entirely wash out the original back-

ground, but he will re-paint and re-cast the picture from time to time. If I may draw another parallel, we can take the graduate, as he leaves his technical instruction, as something similar to a man who is exploring, and in climbing over a ridge he finds in front of him what appears to be an extremely fertile plain. In the middle distance there are foothills, and beyond these a range of mountains, and it is on the top of one of these peaks that the graduate should aim to find the Eldorado of his dreams. I think if he starts off with that, he is showing the foresight that Dr. Anderson has in mind.

Over this plain that he has to travel, there are parallel roads—parallel first, but diverging and crossing after—and it is down one or other of these paths that our graduate must progress towards his goal. Some of these paths are easy, and I want to warn the graduate against those easy paths. They are so easy that he should be just a little bit doubtful as to whether they are really the path that he must go along. It may be that he takes the easy path first because it is easy ; it may be because it offers him a little more money. I would suggest that any path in life that is easy and does not show a distinct and clear outlet towards the goal we have in mind, is the dangerous path. Some of these paths lead to *cul-de-sacs* where you would find yourself either with a crevasse in front of you or an unclimbable obstacle in between you and your goal. These are two essential things, I think, that the graduate should know : First—that he has to paint his own picture ; secondly—he has to keep his own line across the country he is exploring.

There is another thing that the graduate should know, and it is this, that if he hopes to be successful in his path through life to that works managership, or general managership that he sees in the offing, he must know something of expressing his thoughts to others, and the best way, I think, of serving an apprenticeship in that way is to come to our Institutional meetings and to take part in the various discussions. He may say, " I cannot talk." If that is so, he must learn, and I want to tell him one way of learning. When he is coming to a lecture, he should sit down a night or two beforehand and find out how much or how little he knows of the subject on which the lecture is to be. He should definitely make notes where he feels that he is short of information, and however nervous he is (we are all nervous when we are talking) he should get up and ask those questions. Most of our lecturers are only allowed a very short time to develop their subject, so that the lecturer only has time to give us the broad outline of his subject. If we want further information, therefore we must ask the lecturer questions.

Apart from writing down those questions he wants to ask, the graduate should go further, and write down how much he knows about the subject. The moment we start to write about how much we know of a given subject, we perceive how little we know of

it, and there is no better way of improving one's knowledge of a particular line in our business or any other business, than to sit down and write out a rough description of what you would say if you were taking the place of the lecturer. By doing this you will find a number of points on which you have actually no knowledge at all, and these are points you should clear up by asking questions.

One point Dr. Anderson mentioned is, I think, particularly interesting, and it is essential that we should know something of it. It is called psychology, or common sense. This means that you must know something of your fellow men, and if you want to make production engineering your profession, you want to know something of the mentality of those people who are carrying out those duties to-day. The closer you get to them, the closer you get to their mental attitudes, the better position you are in to weigh up their mental attitude and see how it compares with your own point of view. You may see a fundamental difference between your view point and that of other men in the same industry, and when this is the case you should examine your own viewpoint and see whether you can satisfy yourself that you are thinking along correct lines. You get in touch with other mentalities. That is one of the things that you can do at our meetings, but you can only do it fully and satisfactorily by getting up and doing something, such as asking questions.

Our Institution is based on the fundamental truth that those who expect to get most out of the Institution must expect also to give the fullest service they can to that Institution. If we are not prepared to give service to an Institution, then we cannot, I think, expect to get much from it. The point I am trying to make here is this, that whilst you lose nothing by belonging to this Institution —I think you gain something because you get the literature and you read it—you only get the maximum advantage when you come to our lectures and take part in the discussion that those lectures engender. That is a point the graduate ought to know, quite outside anything else.

The aims of the Institution are perfectly clear. We want to place this Institution of ours in such a light that production engineering can really be classed as a profession. Some people will keep on talking about science of production. I want to impress upon you the fact that it is not a science, it is an art. I believe, however, that it can be carried out in a more scientific manner, and we are looking to our graduates to show us the way.

To achieve what he has in mind—the top—the graduate must not only know things, but he must make sure that he can convey his knowledge to others. This he can practise by taking part in our discussions. If he prepares what he is to say, he will also be building up his experience along another line which will be extremely useful to him in the future.

No man can reach the highest positions in his profession without writing a number of reports, and I venture to suggest that all our graduates will improve themselves in this respect if they will follow my suggestion, and before attending a lecture, write down what they know of the subject. They should, too, periodically set themselves the task of writing a report on a specific problem concerned with their work, and this will assist them in two ways. It will teach them how to write a report; it will also provide them with data from which to compile a paper to read before their own Graduate Section.

MR. T. E. WALDECK: I personally, have enjoyed and appreciated the lecture very much indeed, and I am in entire agreement with what Dr. Anderson has said, and I am also in accord with several important points made by the last speaker but there are one or two points which I should like to add in connection with the training required to make an ideal production engineer. I would like to say, as a young engineer, who set out some sixteen years ago with a definite goal in view, and I hope that the members present, will appreciate how interesting this profession of production engineering can be. As a young engineer who had held responsible positions, including that of works manager, I am at present holding a Production Manager's position in an important firm in Birmingham, I think I am qualified to say how interesting this profession is, and can be, providing the young engineer makes up his mind precisely what road he wants to follow in the numerous branches of engineering. There are many pitfalls and many obstacles to encounter before one can reach the responsible positions.

There has been mention made of the all important three-dimensioned power, but I always extend this to three more, that of grit, determination, and personality. Also an important point is the method of approach.

As a college graduate, I set out some sixteen years ago on some definite course, without very much help, although I am the son of a consulting engineer and by working on my own course, it helped me quite a lot, for which to-day I am truly thankful, as by so doing it taught me to surmount the many difficulties. The position of production engineering can be learned comparatively simply, with a natural engineering aiblity, and if the graduate sets about it in a methodical way. The ideal way, I think, speaking from my experience, is this: The graduate should make up his mind at first, to train and follow a definite course, to gain varied engineering experience with different firms. This will take him to numerous places in England, and sometimes abroad on erection work. We should not gain experience in one direction only, but it should be varied on different classes of engineering work, so that when he has

the necessary experience and qualifications, and when he reaches middle age, he can specialise and settle down. He will then have the necessary experience to command one of the better positions.

It is extremely interesting to set about the matter in the right way, but there is a lot behind the study of psychology in industry, as outlined by Dr. Anderson. Personality will be developed by moving through the various branches of engineering during the training days, before you ultimately settle down in some particular branch which you like.

The ideal way which I, personally, have found very satisfactory to follow, is to first, after graduating, obtain a position in a large firm of repute, where you get general engineering experience, by serving an apprenticeship ; after this training to extend by improvership, by going on outside erection work, and ultimately, on erection supervision, which sometimes takes you to all parts of the world, and brings you into contact with different conditions of men, which will ultimately proves invaluable in production engineering. You should then extend your activities by entering another firm manufacturing different products from that of your original firm of general engineers, say on the electrical side, after about three years move to further firm, making smaller and more varied products, such as telephony or wireless, and then if you are fortunate enough to move to yet another—do so. After this training you can then choose which branch of engineering you really like the best, and so specialise, and bring your knowledge into real operation. You might prefer, say, the heavier side of engineering to the lighter mass production side.

This above all comes into the actual training of an ideal production engineer, before you can arrive at a stage when you can definitely choose the branch of production engineering in which you are happy ; which, to my mind, is everything, and if the graduate sets his mind along a royal road, he cannot help, at this stage, of fulfilling his desire.

Mr. Jacobs : I was very pleased to be here to-night to listen to Dr. Anderson's lecture. He has told us what the graduates for production engineering are being taught at the technical school, and I am sure you will all agree that a well thought out programe has been arranged. There is one subject that has not been mentioned, which would be an asset to the student, and that is the measuring of work. What I mean is, how much work can a person do in a given time under given conditions ? This is a subject that Dr. Taylor advocated many years ago, but little progress has been made in this country since then, in compiling data and forming standards so that they can be scientifically used for measuring work.

As you are aware, the measuring of work for rate setting and costing is a very difficult problem and one which is causing more dis-

satisfaction and strikes in industry than anything else. A few weeks ago I had a conversation with three students, who had taken a course in production engineering, and they told me that they had not been taught anything on this subject. I have just mentioned this to show that students find this subject is essential.

From my own experience I have found it most valuable to have standardised data, compiled in such a form that you need not rely on one man's personal views on what he thinks should be. I I should like to give you an illustration. Some years ago, I was talking to a manager of an engineering factory on this subject, and mentioned it was surprising the different opinions expert estimators had of how long it should take to do the same job. He said he did not agree with me, so it was decided to have a test. Four of his men were given a very simple machining job to estimate, unknown to each other. When the estimates were handed in they varied 50%. If some form of standards had been adopted in these works, this could not have happened. I have come across jobs that have the same amount of work to be done on them, but the shape slightly different, and when they have been estimated the times varied 150%.

Mr. E. T. Cook : Having regard to quite a number of young men whom I have introduced at various times into a relatively small works, I have never yet found a man who has got anything like the knowedge that Dr. Anderson has envisaged as to what should be the results of his training. One is inclined to ask why, and the probable reply is that the kind of education Dr. Anderson is proposing has simply not been available. I strongly suspect that is the case, but without perhaps referring further to that aspect of the question, I think I can help us to think a little more about it by considering the way in which various people who have come to me have shown themselves to be not quite suitable for some of the jobs that the young production engineer has got to fill.

First of all, I will say that the unsuitability arose very rarely from lack of technical knowledge. It arose chiefly from lack of personal qualities, and of knowledge of the fundamental principles of science generally, rather than details. Also I have found a lack of ability to work ; and insistence that they get some results for the work they do ; a certain lack of courage, an absence of the analytical mind ; the inability referred to by Mr. Groocock to put down their conclusions from any set of observations they may have to make ; and to deal with a problem as does a chemist by " experiment," " observation," " inference." Any logical conception like this seems to be quite absent from the mind of these young men.

Personally I like to consider things at the beginning of each New Year and to form an idea what results we are going to aim at. In order to give them an opportunity of expressing their ideas, I

sent a request round to my staff that they should review the results of 1936, and based on that, should make recommendations as to what they ought to do in 1937. I have had only two replies, one from a man who is very largely a technical man, and the other from a man who has no technical knowledge whatever. As far as the others are concerned, I still wait—I wait with some interest. I shall consider those reports with great interest—if I ever get them.

Another thing I find personally very difficult, in considering the general aspects of administration, is that little knowledge seems to be available of the fundamental principles of control. I am referring to quite elementary things. For example, when we are considering how to control a works generally, there must be good control over the entrance, and good control over the exit. One must know what things come into a department, and what passes out, and by the difference find out what is the efficiency of that department. Those very simple, elementary things do not seem to be expressed anywhere, and I think if I might suggest it to Dr. Anderson, there is a definite call for a still additional subject, or a modification to some of the subjects already taught, and that is, that one ought to consider as well as actual production the science of production control, so as to give a man who is already reasonably well educated some idea of the general direction in which he should go.

Referring back to the first question, technical education, it is a fact that when you have any particular scientific problem to consider there is nearly always time to consult experts. For example, it is rarely necessary for a man to know very much about metallurgy. If you want a heat treatment for a gear, or if you want to determine the material for a certain kind of job, you can nearly always get very good service from firms who specialise in that kind of thing, and it is therefore not so necessary to know yourself the science of the particular question you are considering; but it is necessary to be able to make the decision that here you should consult somebody else, and there exists a very definite lack of ability to make those decisions, which, I am sure, is much more important than yourself having the ability to solve a particular problem. Those matters are usually so abstruse that to get a real solution you have ultimately got to go back to the expert, so you might just as well start with him.

Mr. J. France: The breadth of this subject, as laid down by Dr. Anderson, is certainly appalling when one is at the wrong end of the stick. It does bring out very clearly, however, that, the student should extend his studies over a wide field, since the benefits of early specialisation are very small. There is no doubt that in following that path in life which Mr. Groocock mentioned, there are very many things encountered which were never visual-

ised when planning the path. Therefore it is much better, as the tendency seems to be in education to-day to treat the subject broadly rather than to specialise.

There is an old saying which I used to believe in very deeply at one time, particularly in considering specialised subjects, that a little knowledge is dangerous, but I have since come to the conclusion that this is a very much exploded fallacy. Anybody's knowledge of any subject is very little. If we have some knowledge, and the means of intelligent application, it does enable us to find some solution ; therefore I do feel very strongly, and I think the discussion has brought this out, that a little knowledge is not dangerous but is far better than no knowledge at all.

Dr. Anderson spoke of fluency in the use of various mathematical and other devices. However fluent we may have become at the end of our technical training, there is no doubt that as the years pass that fluency becomes dimmed, particularly when it is not in constant application. But it is not wholly forgotten, and if an occasion should arise when we need it, it is there at the back of our mind ; we know where to go to polish it up and very quickly we can regain that old ability. I have had that borne in upon me very strongly during my two weeks in Birmingham. Perhaps I ought not to mention this in front of Dr. Anderson, but one of my classes is in Applied Mechanics, and the last time I ever thought about that subject was twelve years ago. I don't know whether the students have detected that or not. But I knew where to look for it. and a very little time applied to the subject has brought it back.

There is one other comment, or criticism, which I should like to make on Dr. Anderson's paper, though it may, perhaps, be a case of fools rushing in where angels fear to tread, and that is, when one comes to go closely into it that paper was built up and this discussion has been built up, round the machine shop. It has been assumed that the student's knowledge of the primary forming processes need be only very small ; but that he must specialise on obtaining knowledge of machining processes.

I should like to put this particular point for the consideration of members of the Examinations Committee. I think it is a mistake for this Institution (I am not speaking of the Birmingham Section in particular) to think that production engineering is concerned with the machine shop entirely. I think a Sheffield audience would very strongly disagree with you. Therefore, in planning our examinations, and syllabus, that must be taken into account.

Again Dr. Anderson, in speaking of foundry work, said that a knowledge of it was desirable but not essential, but surely a foundry man is as much a production engineer as a machine shop man, and developments I think will be eventually to include these other people in just as intensive a course as is now suggested for the machine shop.

Our friend, Mr. Jacobs, has mentioned the measurement of human work not being developed to the exent that it should be. I know from long acquaintance with Mr. Jacobs that this is one of his pet subjects. Very few people have a great deal of information on it; therefore, speaking as a person responsible to a great extent for the teaching of production engineers in Birmingham, if you have any information, give it to us! We cannot dispense it to other people unless we have it ourselves.

MR. GROOCOCK: I am sure I am voicing the opinion of all present to-night when I say how pleased we are to have had Dr. Anderson with us. He has given us a resume of all we ought to know as production engineers, and in our lives, if we progress towards that peak, we shall find the need for that information in some form or other. We cannot specialise in all these subjects—we do not expect to, but graduates know they must specialise in one line and have a good general knowledge of the others. That is the point. There is not sufficient time in life to specialise along all these lines. I particularly sat down last night to think over the subjects that Dr. Anderson would mention, and I think he has mentioned, say a dozen that I did not have on my paper last night. I was going over my own experience—I have been a manager now for nearly twenty years—and I have found always the same position crop up, that when one has to call in the specialists, nine times out of ten the specialist has something to sell, and the management have to decide whether it is salesmanship that they are buying or whether they are buying an actual proposition. If the manager knows anything about the job, he is in a better position to make a correct decision at the time. There is no time to dwell on the job. The problem comes along and has to be dealt with immediately, and the manager himself has to meet it quickly, and to call on his experience and decide, between those two, which is right. He may be wrong, but it is much more usual, if he has some knowledge of the subject, not necessarily specialised, some little knowledge will enable him to analyse two or three propositions that have been put up to him. I do not think we could have had a better lecture on this subject than we have had to-night, and I put forward the proposition now that a hearty vote of thanks be accorded to Dr. Anderson for his very excellent lecture to-night.

The vote of thanks was cordially adopted.

DR. ANDERSON: Thank you very much for such a cordial reception of the paper. I am extremely obliged to you for listening to what I feel is rather a dry subject. The discussion has been quite interesting, and in most cases has really underlined points which I have already mentioned. One speaker suggested that we probably attempted too wide a field. I put it to you that with educational courses there is never time to get in all one wants to get in. One

has to strike a balance between giving the pupil as much as possible, and letting him develop in the time available a reasonable degree of proficiency in the use of that knowledge.

You must remember that all students who take production engineering are part-time students, and that if they attend three evenings a week that represents something like two hundred hours instruction, which corresponds roughly to a months' work. I submit that on the practical side with which you are familiar, you cannot teach a great deal in a month, and all that we can do is to try to give as many principles as we can in order that when the graduate goes through the works, and moves from firm to firm, as one speaker said, he will have opportunities of applying those principles and thoroughly assimilate them developing ultimately a fairly high degree of skill in their application. You have also underlined the importance of graphical methods, and I do feel they are extremely important. Very often, as I said, graphical representation of a problem will offer information which is not at all readily seen, although it is there, in symbols and figures. You have also emphasized the importance of having a three-dimensional mind. It is extremely important.

With regard to too much dependence on measurement, and too little attention being paid to correct principles of machining, I am not competent to make any observation on that, since it is many years since I was in the machine shop.

Mr. Groocock appreciates that we cannot hope to make the finished product. All we can do is to provide a background, and into that background the graduate has to put the finished picture. I think his suggestion that before a meeting of the Institution the graduate should sit down and write out the questions he is going to ask, and jot down very briefly his present knowledge, is excellent, and ought to encourage young people to take part in discussion. He mentioned that many graduates are poor at report writing. That is quite true, and we do try at the Central Technical College to improve that by having in the final year a course on technical precis and report writing.

The third speaker extended the three dimension idea to three dimension character, and I believe, too, that is extremely valuable. Knowledge, of course, is not everything—it must be backed by character. He stressed the very important question of getting varied experience in different works, and if possible, experience abroad. Since I came to Birmingham, we have had a fair number of changes in the engineering staff, and I have noted again and again, getting applications from people who were very well qualified from the theoretical side, but who were limited in experience because they had stayed all the time with one firm. What happens to an application like that is that it is put aside.

Mr. Jacobs extended the question of measurement to measuring work output. That again is rather outside my knowledge, though one must appreciate that you are not measuring such a precise factor as you are when you are measuring an article. It is a more difficult type of measurement, but if we have given the graduate some principles, then he ought to be able to devise some system of measuring the output applicable to his particular problem.

Mr. Jacobs also mentioned the psychology of management, and suggested that the management very often did not apply psychological principles. That, I am sure, is quite true. He mentioned the question of grinding, and the variations in output which one got in grinding, and how, by varying the speed, he increased the output. That is an example of what I stressed in more than one place, the intelligent experiment. We are very far from knowing everything that the machine shop has got to tell us, and there is a vast field of experiment open to the intelligent graduate.

Mr. Cook complains that the young men he has interviewed in the past have not got the necessary knowledge, and he really gave the answer which I am giving, viz., that this type of course has not been running long enough to provide a reasonable output of young men trained along these lines. I hope that when Mr. Cook is interviewing people in five years' time he will find the situation quite different. This speaker also mentioned the necessity for an analytical mind, and drew an analogy with the chemist who has experiment, observation, and inference. That again is just what I was trying to stress—intelligent experiment and keen observation. Keen observation is essential to the graduate who is going to get on. He said also that the simple things in organisation and management were often overlooked. We do try, I think, to include these simple things in the principles of organisation and management which we endeavour to instill into our students.

Mr. France stressed the importance of breadth of knowledge, and said that a little knowledge being a dangerous thing is an exploded fallacy. It is. A little knowledge combined with the proper quality of mind is most valuable. He mentioned the question of applied mechanics, and the difficulty of going back and taking up a subject which one has not handled for some time. I know the situation only too well. I have often been in the position of going into a class one lecture ahead of it, and when I came out we were both level. He mentioned one thing which is a very fair criticism, that is over-emphasis on the machine shop and not enough emphasis on the primary forming processes casting, and forging. These are extremely important and are just as much production engineering as the machine shop side and measurement.

Yorkshire Section

MR. J. D. SCAIFE (Section President) : I have heard Dr. Anderson give a similar lecture once or twice before. It is a very good thing that I made up my mind to be a production engineer before I heard him lecture, or I should never have dared to choose the profession. Dr. Anderson's lecture is quite a sufficient answer to those people who at the outset argued that there was no need for an Institution of Production Engineers. The field of a production engineer is an exceedingly wide one.

I would like to make another observation to our graduates here to put them to the test. I have attended one or two graduates' meetings in the Midlands, and they are very different from the meetings of their seniors. You could not keep them down, whereas usually it is difficult to get the older ones to speak. The graduates were bobbing up just as fast as you could listen to them. This is really a graduates' affair this evening.

MR. J. H. EVERETT : I speak this evening, not as an engineer. which I am not, but as an educationist, which I have tried to be. This paper of Dr. Anderson's must have been interesting to engineers. If you knew all about it, as many of you possibly do, you will have been interested in the way it was presented. It has been brilliantly illustrated, well given, and everyone must have learned at least something from it. His sketch of a graduate engineer fills me with awe—I want to know what a full member ought to know ! Dr. Anderson won't mind my saying that. The way he has dealt with the topic has been most interesting. Now one or two things about the subjects.

It has been interesting to hear mathematics dealt with as an engineer's tool. It is right the engineer should know mathematics, though his chief concern is not so much why a thing is as how he can get an accurate result. It may look very nice mathematically, but that viewpoint to the engineer seems secondary to utility. It is an interesting and not an impossible programme in mathematics. It could be covered possibly in three sessions, certainly in four. With regard to drawing, I forbear to speak about the three dimensions. The remarks about science were very interesting. I am not going to say anything critical about the chemistry course ; I want to encourage the graduates concerned to study chemistry. It is all the more important that a graduate should be very well trained if at the end of his term he is going to face a dignified examination which he has got to get over and pass. I think I can safely say that the syllabus is a counsel of perfection, although evidently it is

necessary for the production engineer to follow the route Dr. Anderson has sketched to-night. What struck me was this problem. Where is the time for all this ? Dr. Anderson referred to five years—sixteen to twenty-one or twenty-two. This problem of time is an important one, I leave ways and means to those more competent. The course will require considerable time and this aspect of the problem needs as much investigation as the engineering parts of the course. The students spend three evenings per week at the college with another two evenings for homework. I want to suggest to-night not as criticism, but as a constructive contribution that the engineering trade itself must handle one side of this course. The engineering trade must not say to the college—*we* send the students, will you please give them this course ? It cannot be done well that way, there must be a closer partnership than there is at present. I want to suggest that the business man must sit down and study this problem. Dr. Anderson has been trying it for years. We want the same thing in Leeds. Industry must take a hand on the engineering side. A scientific course at a college consists partly of lecture and partly of practical work, both closely co-ordinated. When the student was doing a job under the old master of 100 to 150 years ago, the master explained the job before he did it. You cannot afford time to do that properly in industry to-day, so you send the apprentices to a college. The explanation at college may be given one month before or two months afterwards, there is no correlation. If you are dealing, for example, in the college with a question of feeds and speeds and matters that concern lathes or any kind of machine, ideally the student would be best placed if he were operating the machine in the shop the very next day, and all that week, so that his teaching and his work in the shop are correlated. The teaching is too far away from what they are doing. Correlation is definitely wanted. More time is wanted for the course. The required time is not available, the evenings are fully employed. What is the answer ? You in engineering have to find out. I feel if I suggest anything you may say it is not practical. You must find some practical way if you want students well trained. Dr. Anderson has sketched a five to six years' course, in a word he has taken a long view. Training is a long business. I noticed in the newspaper yesterday morning that two engineers had spoken, almost within an hour of one another, one in Leeds and one on the Tyne, and both suggested that there was a shortage of skilled labour in the engineering trade. The suggested solution was this, " Would it not be a good idea to found a training centre to train these people for us ? " How long are you going to give us to train those folks ? Dr. Anderson says it requires five to six years. Can you wait even two years ? Training of any kind is a long business. It is a scientific education that is required as well as a practical one.

I would like to thank you for this opportunity of visiting the Production Engineers in their own quarters.

Dr. D. S. ANDERSON: Mr. Everett has supported a good deal of what I have been outlining in my lecture. I am very glad of his support. With regard to mathematics, I am of the opinion that the teaching of mathematics could be overhauled with advantage. A fair amount of theory could be jettisoned and a good deal more use made of graphical work. With regard to chemistry, the chemical knowledge which I indicated does require a certain amount of theoretical knowledge to precede it. There are more and more pupils coming to technical colleges from secondary schools and a certain number of students come from central schools and these students have a reasonable amount of science training. Quite a fair number have had a sufficient grounding on which to build the special knowledge they require. I think that the whole course could be done in five to six years. It would be a fairly intensive course but an evening course is intensive. Part time day training is the only way by which we can get adequate time and give a really adequate course. It pays, I am quite *sure* that it pays in the long run, because you will build up a body of extremely well trained young people who can help you out with any difficulties. In Birmingham we have had an interesting experience this year. For the first time more students enrolled on the production side than in the ordinary engineering course. The production course has definitely met a real need.

MR. H. C. NEWELL: The workshop production course in Leeds is in process of development. The start is quite a satisfactory one. We have got to measure our coat according to our cloth, and it would not do to entirely agree with Dr. Anderson in offering subjects which are beyond students' capabilities. We shall develop the course to include most, if not all, that Dr. Anderson has outlined. Most of the students know that our work is definitely restricted through the absence of suitable buildings. When that is put right we can go ahead. Students who are able to attend the part-time day training scheme which includes the subject of machine drawing, are not afflicted by the same difficulties as are those who are only able to attend in the evening. Dr. Anderson did mention several points to which I must give support, in fact the whole paper struck me as an especially sound one. It was very interesting, well delivered, compact with instructive data. Dr. Anderson mentioned that since the war the public had become production conscious. The public has become production conscious, and the Government has become conscious of the need for developing technical education also. They voted a sum of £12,000,000 for technical education. This has been allocated up and down the country to colleges and similar institutions where technical education is carried on. This

expenditure in equipment and buildings is really essential if we are going to do any sound work in technical education. It is essential, too, that we have a first class staff. Dr. Anderson will agree with this. He has made a step in the right direction by taking our Honorary Secretary, Mr. France, with him, and I am sure we wish him every success in his new post.

With regard to staffing, when a person who has previously been in industry, is appointed to a full-time post in a technical college in due course he becomes somewhat out-of-date. His duties require him to be present, morning, noon, and night with the consequence that he has little opportunity of keeping contact with industrial development. A person engaged in such duties has not the opportunity of keeping in touch with industry and seeing modern methods. There should be an interchange between the staffs of colleges and persons of similar qualifications in industry. I believe that such a scheme was operated in Germany before the war. Professors in universities went back into industry for periods of five years. If that was the case, there is no question that the reactions, so far as the students are concerned, would be very beneficial. It is most important that the teaching be absolutely up-to-date. Teachers in technical colleges can merely lay down fundamental principles, the students must learn to apply these principles to their every day experiences. For example, it is impossible for technical colleges to give first class instruction in jig and tool work and in press tool work. No technical college could provide the jigs and tools necessary, but fundamental principles can be laid down and it is up to the students, who have absorbed these principles, to apply them in industry.

Mr. G. Booth : Employers should be willing to allow boys who are really studying to go on other machines, and not keep them on one particular job because they happen to do it well. I was working at one firm for a long time. I was a fitter, and there was no possible chance of going on any other machine. They needed skilled men who could tackle all the jobs, and could not get them. A lot of engineering firms in England seem to think that skilled men grow up in a night. The boy's wage when he is young is not a great deal, and firms would definitely help themselves by training boys far more widely than is the present practice in an average works.

Dr. Ward : I have had several invitations to the meetings of the production engineers, but Huddersfield is a fair distance away. I did not intend to speak to-night, I intended to sit at the back and acquire information ; I knew that Dr. Anderson would certainly give an excellent paper. It is not a question of what a graduate ought to know, it is how he is going to get this knowledge. That is the biggest difficulty. Whose responsibility is it ? Is it to be put on to the technical colleges or the employers ? Mr. Everett stated

that there should be more correlation between the technical colleges and employers. Personally, I think the employers are not doing their best. The apprenticeship training of to-day—you can hardly call it such—is definitely poor. An apprentice of fifteen years of age has his heart broken because he is kept on the same kind of machine for a long time. I have known where adults, men who call themselves turners—have come along to the technical colleges to be taught screw cutting. That is wrong. In my opinion, if a man has been trained as a turner he should have had some experience of screw cutting. I was brought up on what I consider the ideal scheme, that is the dockyard scheme, in which an apprentice is moved about the various shops and every apprentice has an instructor. It is similar to the scheme which Mr. Everett mentioned about the apprentice and master. The instructor received 5s. or 2s. 6d. per week for looking after the apprentice. That probably could not be done in a profit-making shop.

The teaching of maths. is a thing which concerns us very much. Whom should it be done by, particularly for these production engineers? Should it be done by a part-time teacher who comes in from a secondary school? Maths. should be taught by an engineer who can introduce practical applications all the time. The subject of trigonometry presents excellent problems that can be set. The man from the secondary school does not know anything about them, the engineer does. In chemistry there is the very important subject of lubrication. I think some of the problems shown on the slides are for the design office more than the production engineer.

Another problem we have in the technical colleges is getting the right type of man to give instruction. In the technical colleges there is only a limited full-time staff, the number depends on the number of students taking the day courses, the majority of technical college staffs are part-time teachers. My problem is to get the right type of man. There is the practical man who cannot teach, and vice versa. There is difficulty in getting co-operation between these part-time teachers. One teaches workshop practice, another drawing and technique. They never see each other. They are probably at different firms. There is often good co-operation when they are from the same firm. It is not done as I should like it done, it is not done satisfactorily. We are trying to do our best.

At a meeting in Huddersfield there was a discussion on various educational problems and particularly about what instruction should be given in a technical college. It happened before I went to Huddersfield. I was very surprised to see that a gentleman suggested that the college workshop should be done away with. He stated that perhaps we could just retain a few machines for teaching, say, maintenance of engines, and so on. The same gentleman who suggested that it should be done away with, at a recent advisory

committee meeting, when dealing with a request for a grinding machine, said : " You must have another grinding machine because I cannot possibly teach them down at my works, I cannot take a skilled man off a machine. You must train them at the technical college." That was the gentleman who a few years before had said that training at technical colleges was of no value.

There is one thing Dr. Anderson has not referred to, that is the getting of information other than by attending classes at technical colleges. They should read engineering publications. I occasionally ask students how many have read *Engineering* this week, and perhaps only one student has been to the library to see a copy. They should read also the papers published by the various professional institutions. A graduate of the Institution of Production Engineers should read thoroughly all through the published papers of the Institution.

I certainly agree with Mr. Everett that this work cannot be done in the evening. I think the time will come eventually when the employers will have to allow apprentices at least one afternoon per week, although three would be better.

MR. MCCANN : It has been my privilege to have worked at several places where the training of apprentices has been done very thoroughly and the system has been that we have started a workshop and instead of putting boys on old machines they have equipped the works school with new plant and the men who have been selected as the teachers in the works school have been what were considered to be the most highly trained men in the plant. The system was that the boys had two weeks in the works school away from production and one week in the shop. Now those boys had to make useful things. They did not make scrap or things that were of no use to the plant. We had all kinds of equipment necessary to the plant. Now the general run of equipment in technical colleges is out-of-date stuff and I think the employers are becoming more conscious of that and it is up to societies like ours gradually to force these facts home and I do not think it is beyond possibility for firms to join up with the education authorities and assist them to equip colleges in an up-to-date manner. Another point is that the teachers themselves, apart from the employers don't avail themselves of opportunities of keeping up to date with modern production methods. I think that the most enlightened employers will grant facilities for the teachers and graduates to have visits to the plants and be properly instructed on the modern methods of machines. We are having a visit ourselves this next week and I may say this is only about the third occasion in several years I have seen a visit of the technical college students to the works, but I do think that the objective and how far they go is largely in the hands of the students themselves. It depends whether they have

sufficient determination to go forward, how far they will study, and what interest they will take in the technical publications of the business they go into. There is no royal road; it is just getting down to it. I have much appreciated Dr. Anderson's paper to-night. I appreciated the shop illumination demonstration. I have learned something myself and I thank Dr. Anderson for his excellent paper.

MR. REEVES: I do not think Dr. Anderson mentioned anything about standardisation of drawings. It is very important that engineers and other people should stress the need for standardisation of layout in this connection. What about two nights per week in summer and Saturday afternoons for lessons? I came here to see what sort of a chap Dr. Anderson was, and how he conducted himself. I would like Dr. Anderson to define an engineer. I am very glad I came. I got in for nothing, but if I had had to pay 2s. 6d. for admission, I should think I had had my money's worth.

MR. R. J. MITCHELL: Nobody could disagree with anything Dr. Anderson has said. One main impression of mine is, however, one of depression—how far practice falls short of precept. It is a strange thing in this country of ours how the Government can spend vast sums on machinery to manufacture the things to kill other people, but when it comes to education, a few millions are doled out in a parsimonius manner which is a disgrace to our intelligence. Those thoughts must have occurrred to many people many times, and will recur often in the future I fear. I have a practical suggestion to make in regard to the supply of trained men. I would abolish the practice of employing young people for profit simply to make them into machine minders. In regard to the supplying of trained men, let us take ourselves as an institution, and it would be a fine thing if Yorkshire were to be the origin of this possible action and thought, and let us put forward proposals along such lines as these. Let us outline a new kind of apprenticeship for a guaranteed training along definite lines at defined rates of pay, which need not by the way be sweated rates of pay, where the indentured apprentice is guaranteed five to six years' instruction, at least half of it to be spent in a full time day course. The cost of it would not be anything like so serious a burden on industry as we are led to believe. If we don't put our house in order we shall risk that in another ten years we shall find that Germany, Czechoslovakia, and Japan will simply wipe our heads off by the unchallengable superiority of their technique. Already as a production engineer I constantly come across exquisitely made equipment produced in other countries than our own which makes me depressed at our shortcomings. I wonder who makes as good a stuff in this country and the honest answer is nobody! nobody! The reason for that state of affairs is that amusement and pleasure *per se* have a somewhat disproportionate status in our lives and a fundamental interest in

education is often lacking, although it is a vital aspect of our national life, and calls for far more serious consideration than it receives. We do not love education and scientific knowledge for their own sake. In our profession, amongst engineers you will find the happiest of human beings, and I do belive that those engaged in the profession of engineering derive the greatest pleasure in life from their job; more so than in any other profession. There is I am confident a vast reservoir of undirected ambition amongst the ordinary working-class and middle-class lads who would wish to attain to a higher type both intellectually and from the craftsman's standpoint. The two aspects are complementary to each other and indispensable to each other. As a nation we are not utilising the means which lie at our disposal to attain the pinnacle of achievement we could reach. We are still probably the most versatile mechanics in the world. It is purely meanness of outlook to withold from the youngsters the means of getting requisite instruction. This business of getting lads in to dead-ends jobs and at eighteen throwing them out on the streets is a national crime and should be discontinued.

I repeat that I should like this occasion of Dr. Anderson's address to us to be the starting point of a definite movement initiated in the Yorkshire Section that education, with particular reference to production engineering, be put on a proper basis from a national standpoint.

DR. D. S. ANDERSON: I was very interested in the discussion, particularly in what some of the students were saying. Mr. Mitchell's suggestion for a course half in the shops and half in the college is an admirable type of course and I should not be at all surprised if we arrived at that ultimately. It would be a good thing if the Yorkshire Branch could start that as an experiment. The Board of Education at the moment are merely toying with it. As an alternative it would be possible to train boys of fifteen years of age as skilled craftsmen in three to four years' full time training, and boys say sixteen to seventeen years of age could be given a three years' professional course of training such as I have outlined to-night. Such young men would be capable of taking responsible posts in industry. Generally speaking (there are exceptions of course) industrialists in this country do not believe in education. They are friendly disposed towards it but they don't fundamentally believe in it. They do abroad. The Ecole Superieure D' Electricite in Paris was built by subscriptions from electric light and power companies, electric manufacturing concerns, and an association of electrical engineers similar to our own I.E.E. It has cost £200,000 to build that school. Ten years ago, certain manufacturing concerns subscribed £200,000 towards the cost of extensions to another of

the leading technical institutions in Paris. Continental companies do believe in training and their craftmanship is of a very high order.

With regard to visits of teachers. Undoubtedly it is extremely difficult for technical college teachers to keep up to date. It is difficult even for industrialists to keep up-to-date. Casual visits do not solve the problem. As Mr. Newell said, teachers should be released from teaching duties for a six month period at intervals so that they can go back into industry.

Evidently students in Leeds are very keen. Mr. Reeves mentioned two nights per week in the summer and Saturday afternoons. Life is not all work, however. There is a danger of making yourself narrow; you should cultivate other interests at your age. Technical instruction is not everything. Overdoing things may injure your health, and it will at least narrow your mind. The more interests you have, the more interesting life becomes. Works schools are of course excellent. Their function is to teach manual skill but that is not the function of the technical colleges. Colleges can teach principles and illustrate the application of those principles. Clearly the teaching of manual skill can be done best in a works school and by going through the works.

With regard to a definition of an engineer. I am not going to be led up that garden path! The production engineer is concerned with manufacturing processes. With regard to the drawing which I put on the screen and did not explain, Mr. Reeves says that it was very difficult to follow. The whole point was to show that it was difficult and that one needed a sound training in solid geometry to read a drawing at a glance. The very fact that Mr. Reeves was puzzled shows how valuable that particular slide was. Isometric projection is of course a very useful form of drawing for showing the form of the article. It gives a quick impression of the outside form better than any other way. I presume the reason why it is not adopted as standard practice in dawing offices is because it does not convey the internal information. With regard to the statement that the teaching of drawing office practice is not standard I would point out that the use of British Standard practice is not universal by firms. A few weeks ago I was attending a meeting of an examining body and it was suggested that British Engineering Standard practice must be adhered to, but one delegate to the meeting did not want that laid down. Some firms use the American standards and others B.E.S. and a person who was familar with one would be at sea with the other. That was the fault of industry rather than of technical colleges.

I do thank Mr. Reeves very much indeed, it certainly is a new experience to me to hear anyone say that they would not mind paying to hear me lecture. Finally, it would not be kind on my part if I did not say here how much help we had from Mr. France in

developing our production engineering courses. He was a member of our part-time teaching staff and his services were of a very high order. Leeds is losing something by his impending departure and Birmingham is gaining something.

Mr. J. D. SCAIFE: It would appear that when Dr. Anderson outlined "What a Graduate should know," he also inferentially explained what a teacher should know. This new activity of ours has brought out the need for some wider ability on the part of teachers in technical schools. That fact, I think was admitted by Mr. Newell. It is all a matter of time before these things will rectify themselves. I think Mr. Mitchell was right when he said that there was something wrong with our industrial activities. I do think myself that employers are responsible for this. I have often expressed it myself that there are thousands I believe who are being paid apprentices' wages and who are not getting a training. They are being exploited as cheap labour. When an employer pays an apprentice's rate up to 21 he is bound in honour to give that boy a training. When that fact is recognised by the majority of employers we shall get very much more assistance from employers in these matters. With regard to the time it takes a boy to get his training, our practice is to engage boys at sixteen years of age and wherever we can we encourage them to stay at school until they are sixteen, that is at a full time school. We find that a boy at that age is physically stronger; he is better educated to take on the amount of training he has to take in the next five years, and if a boy who has been properly educated until he is sixteen comes into a shop he gets moved about from one job to another and by the time he is twenty-one he should have acquired a fair measure of those attributes which Dr. Anderson has pointed out. It requires a lot of co-operation from employers which at the moment the schools do not get.

A vote of thanks to Dr. Anderson was then adopted.

WHAT THE GRADUATE SHOULD KNOW.

Paper presented to the Institution, London Section, by J. Loxham, M.I.P.E., A.M.I.Mech.E., with an introduction by W. G. Carr, Grad.I.P.E.

Introduction by W. G. Carr.

AS Chairman of the London Graduate Section, I have been deputed by our Section Committee to present their views on this important subject, as an introduction to what Mr. Loxham has to say. We feel proud at taking an active part in what we believe, and hope, to be a satisfactory and instructive method of defining and indicating what the graduate should know.

This short paper—or more accurately questionnaire—has been founded on what we believe to be ten fundamental points. In settling these points it at times seemed that the whole subject had been misnamed and what the graduate shouldn't know would take up far less time. However, that is hardly the view to take, and is a very poor foundation for ultimately shouldering all the production engineers' worries and cares.

The first direction in which it was decided that some really sound guidance is necessary, brought us up against a much discussed subject which is not only confined to the sphere of production engineering, namely, the extent of practical training. As these lectures are intended and hoped to be of guidance in post-graduate years, and not prior to taking the graduate examination, we have assumed that by the age of twenty-one or thereabouts, the embryo production engineer has completed four years apprenticeship or equivalent training on sound lines. Having completed this training, what further practical experience is necessary or desirable ? Opinions vary considerably in engineering circles as to what extent practical training influences ultimate success and from which period during the workshop years most benefit is derived ; it is felt that a more clarified view of this subject would be very beneficial. Considering this aspect, we are naturally led on to ask what type of practical experience, particularly in the latter years of training, is most useful ? It would appear that the answer to this question indicates the first line of demarcation between production engineers and designers, whose practical training up to a point will, in most cases, have been on similar lines.

Before passing on from consideration of practical or workshop

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experience, there is one more question we would like to bring forward. That is, " What routine operations are to be as far as possible avoided ? " It has been the experience of some of the younger members that, having become rather adept and useful in one particular section, there is in some cases a reluctance to let them change and gain further experience in another department.

We now come to what, in many cases, has been to the young graduate quite a difficult proposition. Having gained what would be considered sufficient practical or workshop experience, the graduate naturally enough is seeking a position in the office on the lower rungs of the technical or administrative side of the business. What, then, is the best method of obtaining this entry ? Given that circumstances will vary, is it generally advisable that he make this entry with the company with whom he has served his apprenticeship and possibly further experience as a craftsman, or shall he endeavour to join the staff of another company ? Assuming that he has secured a position in one of the many sections which, in one form or another, are directing their energies toward the continuance and improvement of production, can the essential sections he should endeavour to pass through be enumerated, and a brief idea given as to what length of time should be spent in them ? In this connection we can mention such sections as jig and tool design, rate fixing, planning, stock records, etc. It must be remembered that, although to the older members the function and merits of these various sections are well understood, to the graduate they are not nearly so clearly defined. It is obvious, that although all these departments are necessary in greater or lesser degree, some must play a more important part in the organisation than others. For instance, it would seem that to be an efficient planning engineer would require at least a working knowledge of the fundamentals of many sections.

What, then, is the final section that offers the best prospects of advancement to the higher positions, and is there any advantage to be gained in spending some period in specialising in one particular section such as jig and tool design or planning ?

When studying various organisations, it does at times seem very hard to assess accurately the merits of some of these positions, and the graduate is, in his early days, somewhat hazy as to which, apart from personal inclination, is the best position to aim at. We have not, in the production world, with companies sometimes very complex organisations and many sections, a defined method of progress for the young engineer such as is laid down for instance with seagoing marine engineers, who follow very definite steps in their training and progress. The graduate is asking, " Can some such method of progress be laid down ; it it advisable or even practicable for him to attempt to follow some set course to his desired goal in the production sphere ? "

There is one further quite worrying question to the graduate which seems to be connected with the goal at which he is aiming, that is, " What post-graduate education, apart from that gained while at business, is desirable ? " Also, as it is only in recent years that courses for the graduates' examination of this Institution have been given at certain technical colleges " where is he to obtain this post graduate education ? " If it can be indicated to the graduate a route through the various production control sections that is desirable, " Can the main or essential features of these various sections that require special attention and study be pointed out ? "

Finally, we have a question which is, in effect, a summary of the previous inquiries. " Is it, in post-graduate years, better to have a technical training and acquire the general knowledge through experience, or to aim at a wide general training and obtain the detailed technical knowledge by experience ? " We feel that the answer to this last question should do much to save the graduate wasting his time studying various points to a much greater extent than is known to be necessary by the experienced production engineer. In conclusion, we do hope to have aroused by this short paper the main points at least of the many that confront the young graduate when stepping on the rock strewn path to the production engineer's throne.

Paper by J. Loxham.

I THINK the Graduate Sections of the Institution are to be congratulated upon bringing this matter of "What the graduate ought to know" to the forefront in the way they have. My chief duty this evening is to reply to Mr. Carr's ten questions, and add just a few remarks about items which are not covered in his questionnaire. I think we can safely say that the proceedings of this evening will be read by a large number of graduates who seek information on this important matter, and I would, at the outset, express the hope that any of you who feel that you have any real contribution to make on the subject, will do so in the period allowed for discussion.

QUESTION 1: *What amount of practical training is necessary?*

I consider that a wide and varied practical training is the best foundation on which a production engineer can build up his store of knowledge. I know that to the young man in the shops who starts work early, who has a somewhat arduous occupation, involving dirty hands and clothes, the opportunity to be transferred into one of the works offices may be welcomed. I would say "Don't leave the shops until you have learned the major part of what they have to teach you." It is possible to find cases where people have made good with very little practical training, but I think that if the same men had had more practical training, their success would have been even greater.

I was twenty-five when I left the shops to go into a jig and tool drawing office. At twenty-eight, I was chief draughtsman, and the promotion was in my opinion, largely due to the fact that I had had a good practical training.

QUESTION 2: *What type of practical training is desirable, especially in the later years of apprenticeship?*

This question can be answered without much difficulty, but I would like to put in a word of warning here. In the first place, it is not always possible to choose what type of practical work one will do. Secondly, I am not sure that a free choice would be good for a young man. The majority of good engineers look back with pride to the fact that during their apprenticeships they did a number of really difficult, and in many cases, very unpleasant tasks. I remember during my apprenticeship having to file up from the rough both sides of thirty-six brass plates, each of which was one yard square. The job took nearly six months, and I hated it, but I finished it and when it was done I was proud of it. This job gave me a lesson in mastering the art of filing, and mastering

one's self, and in my opinion, the latter was by far the more important. I have never yet seen a person who was continually complaining about his position, make any progress.

To deal more definitely with the question, I would say that the following is a reasonable sub-division of the apprenticeship period :—

15% centre lathe work.
15% milling and shaping.
10% fitting.
15% setting and operating capstan, turret and auto lathes.
10% operating semi-automatic machines, such as gear shapers, broaching machines, drills, grinders, etc.
5% in inspection department.
5% in heat treatment shop.

The last 25%, which is the section specially asked about, should, in my opinion, be spent on the type of work in which the apprentice hopes to specialise.

QUESTION 3 : *What routine operations should be avoided ?*

In reply to this, I would say very few operations should be completely omitted. Do not stay too long on unskilled operations which can be learned in a few hours. There is, unfortunately, still a tendency in some shops, to use cheap apprentice labour for doing work which should be done by unskilled operators. Where this is the case, do not refuse to do the job, do it and do it well, and then complain about it. The man who thinks it is below his dignity to do a menial task rarely makes progress.

QUESTION 4 : *What is the best line of promotion from the shops to the works offices or administrative posts ?*

My reply to this is try to get into the jig and tool drawing office, then into the planning department. If permission can be granted for a period in the rate fixing department, so much the better. This is, however, much easier said than done, and it is the duty of the young graduate bent on progress, to prove to the management that they just cannot afford not to have him in the jig and tool office. This may be done by making application to the right quarter in the form of a revised operation layout and set of jig and tool drawings, describing in a clear and thorough manner how the manufacture of some job at present going through the shops can be considerably improved. Do not make too elaborate claims for the revised scheme, be sure that it is sound, and pick on a job which you know is giving trouble. There are quite a number of such jobs in most firms.

QUESTION 5 : *Should the graduate obtain promotion in his own firm or elsewhere ?*

My own view on this point is that if he can, he should obtain his first promotion in his own firm, then obtain other employment with a

view to obtaining a wider experience. He can probably do this by making himself very efficient and useful and becoming a kind of unofficial assistant to the head of the section. When such a state has been established, he may quite rightly ask for it to be recognised, not so much in the form of extra money, as a small title. Such a person is in a much better position to obtain a really good post with another firm than he would be without this small promotion.

QUESTION 6 : *What section of the works offices should the graduate pass through ?*

The question is very similar to Question 4, and I would say again that the jig and tool drawing offices, planning department, and rate fixing department are the three main and most important offices in which the graduate should spend some time. Other offices of secondary importance, but in which a short period could be well spent, are progress office, chief storekeeper's office, and production or order department.

It is essential that in making out reports of the type I just referred to or in applying for a new position the graduate should name an easy flow of language and that he should be able to put his thoughts into writing. One serious mistake I made when attending school was that I thought an engineer had no need of English. Let me say that I know from experience that English is very important. In many firms it is only by what a person can put on paper that he is able to approach his higher executives.

QUESTION 7 : *What is the relative importance of the various works offices ?*

The most important from the training point of view is, in my opinion, the jig and tool drawing office. A very close second is the planning department. The third is the rate fixing department, and the fourth the progress department.

Here I might add that an important position which the graduate should try to obtain is that of shop foreman or charge hand. The experience gained in such a post would prove of immense value to a potential works manager. Also, I will take this opportunity of stating that it may be worth while to make some sacrifice in salary and position in order to obtain a wider training. For example, a graduate may be, say, an assistant foreman, or foreman with a small firm which has no jig and tool drawing office, or planning department. It would pay him, while he is young, to leave his good job for a position as, say, a jig and tool draughtsman with a large well-organised firm, if he is hoping eventually to make really good progress.

QUESTION 8 : *Is it possible or desirable to lay down any definite line of progress for the young production engineer to pass through as is the case with seagoing engineers ?*

This question deserves very careful consideration. I think it

is possible. Something on these lines has recently been introduced for motor mechanics by the City and Guilds of London Institute, and tests of a suitable type could be devised in connection with the City and Guilds machinists', turners', and fitters' course. This course has an admirable syllabus and much beyond the average machinist, turner, and fitter. By a slight alteration to the syllabus and a re-arrangement of the scheme of examination, I consider that this admirable suggestion could be carried out. I should like to hear the views of other members on this matter.

QUESTION 9: *What post-graduate education is necessary, and where can it be obtained?*

Post-graduate education should be of an administrative type if, and I want to stress this point, the graduate has previously obtained a sufficiently wide technical education. It can be obtained at any good technical college, provided sufficient students enrol. A course of this type is run at quite a number of technical colleges, and full details of those held in London can be obtained from the Education Officer, County Hall.

QUESTION 10: *Is it in post-graduate years better to have a technical training and acquire the general knowledge through experience, or to aim at a wide general training and obtain the detailed technical knowledge by experience?*

This depends very largely on the person himself. If he is confident that he is going to make progress and finally be a general manager or its equivalent, if he is also capable of quickly assimilating knowledge, then the general training is the better of the two. Such a training would be unsuitable for a person who has not the capacity or the desire to undertake the necessary study which would lead him to an executive position. He would finish his training and know a little about a lot of things, but be an expert in nothing. To command a high wage you must be able to do something really well.

I should like to say a little about the contribution which technical education can make to "What a graduate ought to know." The art of production engineering is rapidly becoming a science, and the production engineers of the future must in consequence, be scientific men. The newly recognised property of machinability is an example of how scientific investigation can explain the behaviour of material during machining, and reveal facts which have hitherto been unknown. The graduate should be in a position to read intelligently articles which describe new developments of this type. The many ways in which electricity is being applied to the modern workshop makes it necessary for the graduate to know something of the fundamental laws of electricity and magnetism. To quote only one other case, the graduate, if he hopes to hold a responsible position, should be able to discuss problems concerning materials

with the works chemist or metallurgist. For this, he must know something about physical metallurgy, and the fundamental science underlying it.

To summarise on these points, I would say that the graduate should have a good knowledge of elementary physics and a more detailed knowledge of those branches which, at the moment, affect the science of production engineering. In addition to this, I would recommend as thorough a knowledge of mathematics as the individual can assimilate.

There have been a number of valuable articles published recently on practical subjects, the understanding of which necessitates a good knowledge of advanced mathematics. There will be more articles of this type in the future, and the man who ignores them with the remark that they are too theoretical, is refusing to face the issue. A good working knowledge of engineering drawing and jig and tool design is an essential part of the graduate's store of knowledge. Engineering drawing is the engineer's language, and he cannot express himself adequately without it.

Discussion—London Section.

MR. BLACKSHAW (in the chair): We have listened with interest to Mr. Loxham's views as to what a graduate should know, and I now feel that a paper on "What a graduate should not know" would have been a much shorter one. I can only say that if he could only find a few men possessed of the qualifications he enumerated, then I could very readily find employment for them.

We have quite a number of graduates with us to-night, and I suppose they are by now somewhat bewildered as to the task that lies ahead of them. I have a mental picture of one of Will Hay's scholars—I mean the older one—and am wondering if the reason of his still being at school is that he is hoping to qualify for our graduate course. However, formidable as it may all appear, it is like all big things made up of a number of small things, so that it merely becomes a matter of taking them in hand one at a time, and providing you stick at it you are bound to get there.

MR. A. J. AIERS: Before starting on this discussion, I think we ought to realise that it was due to the members of the Institution realising that the graduate was the backbone of any Institution, and this realisation brought about the discussion which we have had to-night, or are going to have to-night. The graduates form one of the most important parts of the Institution of Production Engineers, with the result that the Council recommended that a paper such as we have had to-night should be discussed.

We should do well to congratulate Mr. Loxham on the very fine description of the way in which technical classes are run in the colleges, but the graduates know of those courses, and I think they realise the benefit of taking them. But it is something else they want to get hold of—what are the pitfalls to which they are liable to fall into? The biggest one which has been mentioned is the danger of getting in a groove and of being unable to get out of it. I think we should do well to leave the technical studies and the excellent courses on metallurgy, which I agree are excellent, to the technical colleges, and try and get down to some of the more practical things that graduates will come up against.

The first one is the danger of getting in a groove. We all know graduates, students, and apprentices who are quite good. You find it necessary to open new departments and you put them in positions where they are excellent, especially on detailed work, and you feel frightened to move them because you are afraid that, if you put somebody else into their position, they will not be so good;

they will not have that capacity for detail, and they will let the department down.

The next pitfall is that after the graduate or student or apprentice has had his varied training he thinks he would like to spend the last six months in the design office. He goes into the design office and finds it is a nice office, to which he can go in his clean clothes. It is very comfortable, with the result that he leaves the hard path of the production engineer and settles down to become a draughtsman. Mr. Loxham has pointed out the good points of that, namely, that instead of the design office graduates should endeavour to enter the jig and tool department office. I think that if you are in a factory which recognises that the apprentice must get down into the shops and get hold of those problems, which often are left to the jig and tool draughtsman, then it is a great help.

As regards practical work, Mr. Loxham has partly stressed that the practical work depends on the lathe, milling machine, and grinding machine, etc. I should like to go a bit further and put some of the practical work and necessary work in estimating, progress, and planning. It is not theoretical work ; some of it is really practical, and graduates will come across a lot of snags connected with production engineering. I agree with him about the three main departments which they could go in, namely, estimating, planning, and jig and tool, but I do think we should carefully examine these departments. Everybody knows that you can go in the planning department of one firm and it may be only very simple routine work of a clerical nature, and you can go in a planning department of another works where real planning is done and routine work is left to clerks, and they really get down to ideal planning. The office have draughtsmen making the proper layouts, revising assembling methods, where useful information can be obtained whereas in going into other departments of works it is so very easy for the graduate to get into some routine job where he is liable to stick.

The next point regarding " Should a graduate try and escape some of this ? " I say " No ! " Everyone should go through all of this work and try and take up all the really bad tasks so that he will, later on, realise the inefficient methods by which some of these routine jobs are done and try later on when he is in the position to do so to eliminate them by mechanising some of their duties. It is only by having to put up with these difficulties that he will realise the pitfalls.

Next, as regards " In what order he should go through the departments ? " A very simple one I think is to go through the departments in the order of the works flow. First of all a short time in the order office where the material is ordered, then in the goods received

and issuing department, then planning and estimating, rate fixing, inspection stores, and despatch.

As to whether he should carry on at the same firm or go to another, I think this depends every time upon the graduate and the type of workshop or works at which he is employed. If it is a very large one it is more liable that he will get into a groove. Then I think he should move and go into a small firm where he can get the privilege of going through each of the departments, finding out the snags, but not stopping in any of them.

With regard to the length of time—I think it is hard trying to fix a time. We all know that as Mr. Loxham said, some of us do not like certain things. Therefore, we need twice as long in that department to find out the snags. It would depend partly on the graduate.

A point which has not been mentioned to-night is that if a graduate is keen he will not only use all the time he is employed, but very often he uses all his spare time in trying to obtain knowledge of the different jobs, with the result that he forgets that the one most important thing is health. Very often he has a breakdown in health, then nobody wants him. We only want men who are really alive. In every case the graduate should realise that and deliberately set apart part of his life in healthy recreation.

Finally, he should visit other works and trade exhibitions, and the last item which the lecturer has mentioned, a course in industrial organisation and management. That, I think, is one of the most important points. Before the lecture I was going to say that I did not know of anywhere where it is in the curriculum of production engineers, but I am very pleased to hear that there are such courses, and I am very pleased it is one of the points that was stressed.

Mr. W. A. Melhuish : May I commence by congratulating our two speakers for bringing forward a very debatable question in a most able way. I was very pleased to hear that there is going to be a series of discussions in the provinces. I think it is time we got down to the question of what a graduate should know. He, the graduate, is the backbone of our Institution. However, Mr. Aiers in opening voiced somewhat my own views. We ought not to decide on what a graduate should know, but what he should not know. It is in my mind the way in which the paper should be presented. For a number of years I have also lectured on factory organisation and production methods and organisation. In drawing up the syllabus of that course I was always confronted with the difficulty, what shall I leave out. It is the real snag that the graduate has to come up against, what things they can leave out looking at it from a production engineer's point of view.

I am rather disappointed to see item No. 5 "Should the graduate obtain promotion in his firm or elsewhere?" I was employed for a good number of years by a company of factory organization management engineers. It was our task to go throughout Great Britain organizing firms and we also went to the Continent and to the Colonies, and with such experience I have realised that no two firms are alike. I have also realised that the graduate who has spent all his time in one firm makes a very good storekeeper in the finish. I know very few production engineers who have been in one firm all their lives who are production engineers. My present job may be motor cars, my next job might be dynamos and I would know nothing whatever about it unless I have had a wide experience. Specialised production does not apply in general engineering. We have one Austin Motor Car Company and one Ford Company, but we have thousands of companies in this country which we cannot classify in a definite category. We often forget the general engineers and the firms which are not definitely engaged in manufacturing standardised single products. This work presents an entirely different proposition to the production engineers. My experience on the matter is that the best production engineer, the best graduate who is becoming a production engineer, has worked in a number of companies. I say, do not remain in a job where there is no advancement. If you are in rate fixing in one company, chuck it and get a job somewhere else. By changing from different companies you become one of the best production engineers possible. I think our friends in the U.S.A. have much to teach us in that direction.

I was also very surprised to hear about production engineers who take a little rate fixing, then a little progressing, and a little planning, and that he should also be in the ordering section and the despatching section where he is not always on production work. The production engineer or planning engineer surely combines all these. I am at present the planning manager of a company in London and it is my job to order the material, set the rates, progressing, making out the operation sheets and so forth. In fact surely the production engineer, whether he be a production engineer or planning engineer, combines all these. The production engineer who has not been through them all will never become a production engineer.

I was also surprised to hear Mr. Loxham say something about the graduates who are slow at learning and who are out of work and who get in the ruts. Is our Institution different from others that we should try and side with abnormal people? Whilst we can give a graduate the best practical and technical experience possible, if he cannot grasp it he will never become a production engineer, but I think the most important question is missing, and that is personality and initiative. I have good men working for

me, I have had them in other companies, and they will never become first class production engineers because they have no personality or initiative. Whatever amount of knowledge you may have you are not going to be very successful without these qualities. You may have a good man working with you training to become a planning engineer, he may be able to order material and discuss drawings and specifications with anybody, yet probably lacking in that personality and initiative which is necessary to those who wish to become production engineers. Get this one thing behind your mind and ask yourself of everything " do we really need it," and I think you are far nearer towards becoming a really first class production engineer if you can answer that question.

It may seem that I am criticising the questions very harshly, but I hold decided views on what a graduate or a production engineer should know or do. I have been in many different countries and studied these things, and even if I criticise, I do heartily congratulate the two speakers in so ably bringing forward a most debatable point.

MR. B. H. DYSON: I think I had better take the side of the graduate for a while as everyone seems to be a little against him, and very keen on telling him of those things which he ought not to know and do and those things which he ought to know and do. In taking the graduate's point of view I feel like using the title given to a recent series of radio broadcasts, and so with the backing of the graduates will say " I protest."

It has been my privilege to be a lecturer at a " technical college " on the subjects of works organisation and management and industrial administration, the syllabus of which are approved by the Institute of Electrical and Mechanical Engineers and by our own Institution, the examination results of these courses are also recognised as exempting sections of the graduate examination.

You will appreciate the fact that the students attending these courses are fellows of a pretty high standard or they would not have the enthusiasm to attend evening classes, they are generally from eighteen to twenty-five although I have had enthusiasts of thirty-five years of age. Believe me, when you get a batch of twelve to eighteen of this calibre in front of you, you soon begin to realise what the graduate wants to know, in fact you soon realise what you need to know yourself.

Well, in my experience in giving these courses of lectures I have made it a point, at the end of the session of giving the students a chance of stating their definite opinions on the course of lectures we have taken. I do this for several reasons, and I get some quite interesting remarks, some of them quite personal, some of them quite con-

structive, and I thought gentlemen, you would like to hear a few of these remarks, and I am taking the opportunity of putting these before you. One student says, " Although realising the need for organisation such as has been dealt with, there is such a wide difference between this and the average engineering concern that it seems unable to be made use of." Another student says, " the pity seems to be that only a small percentage of works managers have the knowledge of these subjects at heart." How can a subordinate create or maintain the high standards of efficiency required when the department heads refuse to acknowledge efficient organisation and management. It is known perhaps that they are not qualified, but how can a subordinate overcome this ? Another student says, " I fail to see how one can put the knowledge we have gained into practice as we are not in the chief's position and most chiefs are not interested in organisation and management." Another student says, " By our studies we now realise the fundamentals in the various functions of management, but we find all the positions in which these can be applied are filled with people who have grown up with the firm. Another one, of a different tone, to add a little spice to the subject asks, " Would it not be better to retire labour at an earlier age than the present sixty or sixty-five ? " The last question was answered by the following story. At a certain well-known hotel there were two young bell boys of about fourteen to fifteen years old, in a fed up frame of mind, one told the other that he had been employed at the hotel for a year, but that he was miserable and hated the job. The other in reply asked, why, if he did not like the job, did he still carry on with it ? He received the reply, " Well if I stay, in forty years time I get a pension.

My reply to disappointed graduates, is, that to-day's graduates will be to-morrow's directors and managers, and that therefore to prepare themselves for this responsibility is essential, in order that, when they hold the key positions, the graduates of the time will not have reasons to complain in the same way as they are complaining.

I must say that Mr. Loxham has given me a lot of food for thought, and several good answers that I can make use of. I myself followed the lines that he has explained to us, of illustrating the difficulties and to show students how they can overcome these. There is no denying the fact that this training of the graduate for future managerial positions is one of managements obligations and I am rather disappointed to see several vacant chairs here this evening, it is a pity they are not filled by directors and works managers. I venture to suggest that our Institution might formulate from the series of lectures that are to be given on this subject of graduate training, the training and fundamentals that are essential, and

that copies of this should be circulated to all manufacturing companies.

I was very pleased to hear the question of estimating raised, because personally I have found that this is one sphere that seems to be sadly lacking. In interviewing toolmakers, on showing them a drawing they will often give quite good answers on how they would design a tool, or how they would make it, but very few seem to have any idea of how long the tool should take to make. I have also repeatedly come up against this question with apprentices in the shops, they invariably consider that they have only to learn how the job is done and have little if any regard of how long the job should take to do. I invariably point out to them that the drawing to which they are working calls for a certain dimension, of say, 1.625 in. $^{+.003}_{-.003}$ and on asking to what size they are working receive the ready reply 1.625 in. I then show them that the accompanying operation layout calls for the operation to be done in 1.25 minutes, but on asking them how long they are taking to do the job, the answer is that they did not think that mattered. Well obviously as every good engineer knows, it is as essential for the graduate to know how long a job will take as it is to know how to do it.

Mr. Kirchner: There is one outstanding feature which has struck me and that is that nearly the whole of the discussion to-night, together with the paper itself, turn about the words "works manager." Why? What is a works manager? Although I do not speak with a number of years of experience I can say that in the course of my professional duties I have met many works managers, very few of whom have similar types of job. I may go into a small factory and find that this particular gentleman is the chief accountant, secretary, sales manager, and many other things, whereas in some large establishments I have met works managers who are little more than "company sergeant majors." Their main duties appear to be to ensure that everyone commences and ceases work at the proper time.

The object of to-night's paper is to outline the many things which a graduate should know, and it seems to me that all the paper and discussion have been directed to the problem of making him suitable to become a works manager. I would like to suggest that there are other posts in the field of production engineering which are equally as attractive particularly in view of the fact that the works manager is not always the head of the concern, and I feel that this position should not be held out as the ultimate goal for every young production engineer.

As an example there is technical salesmanship which often offers

much better reward and calls for just as much experience and probably considerably more personality than works managership. There are also lesser jobs in the generally accepted sense such as that of chief jig and tool draughtsman. Many a works manager of a small concern might have been the chief jig and tool designer of a large works at perhaps double the salary had he but realised that jigs and tools, perhaps even only press tools are a subject to which one can easily devote a lifetime experience. Mr. Loxham has shown us slides of press tools as part of the knowledge which a graduate should acquire, but I am sure he will agree that these only touched the fringe of the subject. The same remarks may be applied to die casting and bakelite moulding. Even to-day there are very few people, I say this with all modesty as I myself know very little about it, there are very few people yet who can claim to be experts on bakelite moulding. In conclusion I would repeat that it does not seem necessary to me for graduates to aspire to be a works manager: in fact in many cases I would submit that if they settled down to developing into a chief jig and tool designer or technical sales manager they would have quite enough to last them all their lives, and it is probable that in doing so they would go much farther up the ladder of success than by aspiring to be a works manager.

A VISITOR: Can a senior member inform a younger student why he should not necessarily have a burden of responsibility placed upon him during his tuition? The majority of courses seem to lack in this direction, which I think is due to an over concentration of the curriculum concerned. I honestly think that responsibility does increase our mental capacity.

MR. D. BRAID: I should like to know the procedure in other firms for the graduate choosing a career when he finishes his apprenticeship. I was apprenticed in quite a large firm where they ran an approved apprenticeship system and you were sent round the factory by an apprenticeship supervisor. As I approached the age of twenty-one he asked me what I would like to do at the end of my apprenticeship, and I said I would like to go into the jig and tool room. It was arranged that I should go in there and after I had been in there a few months, at the age of twenty-one, the manager said, "What do you intend to do now?" I said I would like to stay at the tools for a year or two, and he said that was a very good idea and if I spent five years at the tools and carried on with my studies they could offer me quite a reasonable chance of promotion. At the same time he told me not to stay in the tool room too long, he told me to get out into the production shops as well and it struck me that that was very sound advice on his part, because I endeavoured to carry out his views and they certainly

gave me promotion at the end of the time. I would be very interested to know if that is the procedure at other firms or whether you are allowed to go on and drift along as anyone thinks fit.

MR. WHITLOCK: No senior member seems to be answering the last gentleman's question, so I should like to ask Mr. Loxham a question. He said that if a charge hand or a foreman felt that he could take the risk, it would possibly be worth his while to take a lesser job as a jig and tool draughtsman, with the hope that he would possibly get a works managership later on. Supposing a young man has been fortunate enough to spend several years in the shops and two or three years in the jig and tool drawing office, and a year or two in the rate fixing office, do you think it is worth while at that time him taking a job as a shop foreman in the hope of getting into the offices again? It seems to me that after you have left the office and gone into the shops it is rather difficult to go into the office again. I would definitely like you to answer that question.

MR. PRIOR: There is one thing about production engineering, and that is that you have to make things and to make them you have got to use people. You have people trained to use people. In the engineering trade it is usually a matter that a good man is given a job in charge of other people. He takes charge of them and that is that. The manager goes round occasionally, sees the man in charge and if there is any trouble wants to know why things are not turned out. If they are turned out it is all good and well. The man has never to do any real thinking. All he needs to control the people is an elementary knowledge of psychology and that sort of thing. If you go to an academic course or lectures they do not directly bear on the production engineer's problems. The production engineer's problems seem to be to some extent divorced from the academic side of things. He has got to consider possibly a lower grade of person than he is used to mixing with. That is in itself a very big difficulty that no untrained man can get over. That seems to be a point that everybody has missed this evening.

MR. OAKLEY: It appears to me that all this works and technical training of which we have heard for the graduate and post graduate so as to fit them later, to fill the various important administrative posts in our factories, is very interesting and most necessary, but to my mind we will still have many of these young men lacking other very vital knowledge, which is also necessary for success in this field. We can leave to the technical colleges the responsibility for the necessary technical and scientific data, and to the works for the training which is obviously most essential for the groundwork of experience. To successfully fill these higher posts later on it seems to me that continued time and study must be given to acquiring the ar of understanding men. Our great need these days throughout

the country in my opinion, is that we have not enough of the right calibre in the personal controlling and running our engineering works. We have many men that are most capable both on the works and office staffs, but the whole secret of production engineering is the working and pulling together of these various officials and departmental chiefs throughout the works and offices.

We would do well as production engineers, especially the graduates of the Institution, to add to their qualifications something of the psychological side, and then I think we should have gained valuable knowledge, which will strengthen the qualifications before mentioned and prove very useful later on when called upon to exercise their experience and judgment. It is important to have those factors working together, and I think that most directors in all our concerns invariably find when they have secured men for executive posts, such as works managers, production engineers, and leaders of technical departments, that they are not a complete success, because they lack the necessary skill in the placing, handling, and pulling together the men under their control.

Every man employed has a place to fill somewhere, and I feel that many responsible posts in our factories to-day are very often filled by men of the wrong type, but are there by outside influence or probably they have the power of driving those under their control, which never succeeds anyway ultimately.

You often have bad feeling and if you have this you do not get the full and efficient output. I would stress that one point, as many points of view have been stressed this evening, but this does strike me that if we could consider more of the psychological factors, so often overlooked, and build up the personality and character, I feel that there is a great advantage to be gained by such consideration and I am not being sentimental when I say that. In other industrial firms outside engineering you will find that they are placing university and well educated people into the different positions of responsibility. Why is it ? Because they have specially studied the whole view of life and experience and character, and all that goes into it. They do not usually possess expert engineering knowledge, which of course is always an asset, but they wield wonderful power because they have personality and leadership.

MR. BLACKSHAW : We seem to have digressed somewhat during the discussion for the focus appears to have been " How to become a works manager," rather than "What a graduate should know." Well, I happen to be one of those unfortunate individuals—I say unfortunate, for I am convinced there are better things in life than that of being a works manager, but that is only just my opinion.

Unfortunately, no one told me when I was younger, and I am afraid it is rather late in the day to start all over again.

What a graduate should know according to our lecturer is one thing, but to my mind there are other factors which have a real significance. I often say life is a gamble, and as some of you must know there is many a good man at the bottom and many a dud man at the top. One often hears the expression " How did he manage to get his job." Well, that is what I mean by the luck of the game. Again there are circumstances, maybe domestic, which prevent a man from following his bent, or it may have been that all the advantages of technical schools, etc., were not available to him. It is not given to every boy to be either guided or to have that something in him, call it what you may, which will get him along. I have known of many cases where men were excellent engineers whilst in the shops, but when given the opportunity they did not get any further, simply because they were incapable of shouldering responsibility. Again, there is the type of man who has all the qualifications as an engineer, but who is of such a retiring disposition that it prevents him from ever coming to the front, and I do suggest, therefore. that if the graduate has in mind what he wants to be that he first of all puts himself through what I would call " self-analysis." I wonder how many men ever sit down and ask themselves the question " what am I ? " It can be done, and if a man is perfectly frank with himself he will know his strength and his weakness. I commend such a course to all graduates, and then when you know where your strength lies follow up for all you are worth.

I know parents are often at a loss to know what profession to put their boys to. It is certainly difficult, because it is not until one is older that one realises whether they have done the right thing. That, of course, is why we get so many square pegs in round holes and I am afraid it will always be so. One thing, however, is certain, and it is that if such a course is followed as has been described by our lecturer to-night, and provided they are of normal intelligence, then it will certainly take them a long way along the path which they wish to traverse, for they will then be prepared, at least technically, for any opportunities which present themselves. The point that Mr. Aiers raised re health is certainly one not to be overlooked if in fact it is not the most important of all, but like some of the characteristics we have referred to to-night, you either have it or have not, it cannot be bought. If you do not enjoy good health, then I am afraid you cannot hope to go far along any road. Again, there is no royal road to becoming a production engineer, and my advice to all graduates is to learn all you possible can so that you can grasp opportunities as they come along.

MR. LOXHAM: I will try as well as I am able to reply to those many varied and very interesting questions. I have talked a little bit about science, but how to become a production engineer is not a science—there are no fixed laws about it. It is a thing about which different people have different views and that will continue to be so for a very long time. However, my views on the points that have been raised are along these lines.

One of the early speakers mentioned the difficulty of getting into a groove and how to best get out of it, I am of the opinion that the majority of works managers are reasonable men. I remember the managing director of a firm saying publicly that the responsibility that the firm had to its employees was far greater than its responsibility to its shareholders. It was a fine thing to say, but I do not think that it is at all unique. I think that there are quite a number of firms that have that good outlook, and I should say that if you are in a groove and have been in it a long time, do not complain until you have got something to complain about. That is the thing that the management do not like. If you are in a groove, you go to your chief, whoever he is and say, " I do not know whether it will ever materialize, but I had hoped to equip myself for a reasonable position, and I thought that my experience here would fit me for such a position. I have worked hard. I have done this and I have done that, but I do not seem to be making the progress that I ought to do, because I have been on this job too long. I should appreciate your kindness if you could give the matter your consideration and arrange for me a move of some kind. I do not want it immediately but shall be pleased to have it when you can fit it in with your arrangements. Say something on these lines, and, I cannot think that a request of that type would be turned down flat. If it is, leave, that is the only thing to do.

The question of draughtsmen was referred to and the desirability of going into a jig and tool drawing office in preference to the designs office. I think that is very desirable, very desirable indeed, and I think that if a young production engineer goes into the designs office, as a production engineer we have lost him, but if he goes into the jig and tool office, we have not. He can move from there into rate fixing or planning—something of that kind—and could aspire to other jobs on the production side.

The question of real planning, I think, was then referred to, it is unfortunate that we have so many different departments, which are called by the same name. One planning department may be something that almost runs the factory, as an example was given. Another quite a small thing that maybe issues order cards or something of that kind. A man that can control a full planning

department, a man that has had experience in a full planning department, is of course is an admirable production engineer, and such a department is one that we should try to have experience in.

Health is a very important point and I was rather glad that that was raised. We as production engineers know something about mechanics. We might look at a complicated automatic machine and think we shall have to treat that carefully or else it will break down, and when it breaks down it will be difficult to repair. We ourselves are of course the most complicated mechanism conceivable, and we never close down for a thorough overhaul. Your heart started beating when you were born and it will have to keep on running. You cannot close it down for a fortnight while you overhaul it, and if you live a long time, you will be more serviceable to the world, and therefore it does behove you to look after your health.

I think self examination is a very admirable point and should be applied to health. If you know you cannot do a thing, do not try. On the other hand, if you feel you have plenty of reserve you can draw on it if the conditions justify it. You can usually feel how far you can go. I recently had a bit of trouble with health and I know how far I can go, and I am not going to be silly and do things which I know would knock me to pieces.

The question of works and trades exhibitions was referred to. I think that too is an admirable thing for graduates to note. With regard to works visits, I had wondered whether to put this point in my paper. I am inclined to think that a lot of the works visits we go to are generally a walk round, a general survey of the whole thing. It might be better if you wrote to such and such a firm and say that you would like to examine some department and would be pleased if they would allow some responsible person to be there to explain the working of that particular section. You could spend an afternoon in a heat treatment shop that was well organised and you could learn quite a lot. You could do an inspection department another afternoon and learn a lot, and visits of that type I think would be very very valuable to graduates. The great thing, you see, is for the young man to have some knowledge of how other firms do things, and just looking at their furniture and having a general survey of the whole factory does not teach him very much. It would be a great advantage for a man that is working in a small factory that is doing very little in the way of inspection, to go into a well organised inspection room, and see how parts are very carefully inspected. It would open his eyes quite a lot and do him a lot of good, whereas to just open the door and say, " This is our inspection room " and go out again, he has learnt nothing at all about it.

The idea of what the graduate should not know was stressed and I think there is a lot in that. I dare say we could enumerate a number of things which experienced people have found were not worth wasting time on. I think such a list would be quite valuable. It sounds rather negative but it would be useful nevertheless. I do not know that I could enumerate such a list. I have not the time and I am not sure that I am capable.

Slow men were referred to and in this I am going to stand up for the slow graduates. They are good men, some of them very good. A man might be slow but he is thorough. A man may learn some things slowly, but when he has learned them he remembers them, and I would say that a slow man would make an admirable expert on, say, press tools designs if he has got a whim in that direction. And here the point of self examination comes up again. If you are the person that seems to like to go into things thoroughly and get things 100% right, or as near that as you can get it, and spend a lot of time on it, and do it slowly but thoroughly, you are the man for work of that type—press tool design, jig and tool design, research work, or something of that order, but certainly not for the position of any executive where you have to make quick decisions. Your mental ability is quite unsuited for it. On the other hand, you have been made in the way you are. There is a job for you and a job that you can do well, and this admirable suggestion of self examination I think would help quite a lot to pick out the job to which we are best suited.

Then came the very vexed question of overcoming a poor chief—maybe someone who is not as clever at his job as you are and he is rather jealous. It is a very difficult situation, there is no doubt about it—very difficult. My only remarks on that are that you should be very honest with him. Do not give him the slightest opportunity to think that you are going behind his back at all. Give him all the help you can. Go to him and say " I would like to take that job on for you " and "I would like to put that through for you," and then when you have put it through and there is any credit knocking about, say " we did this." We did not do it at all, you did it. It pays handsomely to do this sort of thing, your life is happier, you will be tolerated in the department until your chief will eventually begin to believe that " this fellow is a useful sort of man to have, I must keep him and give him some encouragement."

I think estimating was the next point that was referred to. It is very important, is estimating. I was rather slow to leave it out, but I had thought that it was covered when I referred to rate fixing. You have a separate estimating department in some cases, and in some cases the rate fixing department do what estimating is to be done. But estimating is very important. In some firms

it is of vital importance. Say, for instance, that there is a drawing for a tool and four firms have been asked to quote for it, and the firm that quotes the least price gets the job. Now if you have quoted a ridiculously low figure due to bad estimating you will lose money on the job and you would be better without it. On the other hand, if you quote too high a figure you will not get the job at all and get no profit on it. So you lose both ways by poor estimating. It is a very important department.

The time to do a job was raised. This is also very important. Not only should a good job be made, but a good job should be made quickly. I was employed for some time with a firm which made textile machinery, and if you know anything about this class of work you will know that it is not a very high class job, and it is essential that it should be turned out cheaply. I went on a visit one afternoon to a Rolls Royce factory and met one of my old colleagues and I saw some of the absolutely wonderful work that he was doing, but in conversation with him afterwards he said, " It is easier to make Rolls Royce engines than it is to make looms." He said, " We have plenty of time to do it in. We have nice conditions to work under and you can work until it is a really good job. If you have to scrap it, why you make another." If you are making looms you cannot afford scrap, otherwise the profit is gone, and you have to make them good enough and quickly.

Specialization on press tool work was referred to. Press work is a good line to specialise on. I have a few photographs here on which we can spend a few minutes. These photographs represent the kind of work that a man who specialises can do. It is the sort of thing that the slow man would do, and do well. The first is a micro-photograph of a dead mild steel, and you see it is somewhat like crazy paving. If this material is strained as it would be in making a deep cup.

A knowledge of plastic moulding was referred to. Here again, I would say that any new process of which plastic moulding is an example is likely to arise at any time, and the man who has a good fundamental knowledge of elementary science is able to apply that knowledge to anything that might arise.

The question of leaving the offices for the shops was referred to. It is a very difficult problem, and I would recommend the other way round, but not leaving the offices for the shops. That is why I stressed the point of stopping in the shops at the beginning until you have learnt everything that it is necessary to learn there, but once you have left the shops I do not think, unless the circumstances were rather exceptional, it would be wise to go back again.

The question of character that was raised is, to my mind, admirable. There is nothing gained in trying to take short cuts and go behind

people's backs and doing unfair things. If you cannot make progress on straightforward honourable lines, well you are best stopping where you are. Our admirable chairman apparently passed through a hard school, so he tells us. It is the best school to pass through if if you are strong enough to do it.

A vote of thanks to Mr. Loxham and Mr. Carr, proposed by MR. CHILDS, concluded the proceedings.

WHAT THE GRADUATE SHOULD KNOW.

Paper presented to the Institution, Coventry Section, by J. W. Berry, M.I.P.E., Member of Council, Chairman, Joint Examination Board and Examinations and Research Committee.

WHEN first I accepted your invitation, I had anticipated talking to your graduate section only, but, in view of the fact that my audience includes many who are in controlling positions, I propose to broaden the scope of my talk. Although I am deeply conscious that there are many others who are far better equipped to address you on this subject, I will do my best to put over some thoughts which will promote discussion, and, if any thanks are due to me at the end, they would be best expressed in the volume and quality of the discussion which I sincerely hope will follow.

In answer to the question implied by the title of this paper, I propose to divide my remarks under four main headings: (1) The opinion of the Institution; (2) the opinion of educational authorities; (3) The opinion of industry; (4) methods by which this knowledge can be gained.

The Opinion of the Institution.

The educational side of this Institution owes its inception to the pioneer work of the late Mr. Harry Mantell, and we owe a great debt of gratitude to him, for his work in this direction. A Committee was appointed in 1928, which reported in favour of an examination scheme for graduates, and drew up in outline a syllabus for this purpose.

In 1929 the three technical and art associations were approached, and a conference was held in London in 1929, at which the writer was present. From that meeting, the co-operation between your Institution and representatives of technical institutions began; culminating in the formation of the Joint Examination Board, of which I have the honour to be chairman. Although we cannot claim full credit, I am firmly of the opinion that our efforts have in no small way, helped the growth of technical training for pro-

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duction engineers, for, whilst in 1927 the number of students was 5,367, in 1934 that number had increased to 12,154.

It is interesting to record here the first syllabus, and the first idea of this Institution, on what they expected the graduate to know :—

Works Organisation and Practice.

Part I.—Forms of organisation and their uses. Scientific management, and its application. Departmental organisation. The storing, handling, and movement of materials. Limit systems. Considerations affecting the construction of works, in respect of locality, power, heating, lighting, water, and transport.

Part II.—Workshop drawings. Criticism of design to facilitate production. Machine tools and their uses. Operation planning. Jigs and tools, etc.

Economics and Commerce.

The definition of terms used in elementary political economy. The application of elementary economics to industrial questions. The influence of Home Office requirements upon industry. Employers' federation and trades union regulations. Payment by results. Profit sharing. Co-partnerships and other systems to encourage output. Costing. Control of purchases. The relation between sales and production.

Psychology.

Speed and accuracy of thought. The association of ideas. Power of observation, initiative, and originality. Handling of personnel.

These subjects were to be preceded by an essay which was to be done at home. The main object of this essay, as is the case to-day, was to obtain some idea of the candidate's outlook on industrial life. He was allowed free access to books, and the nature of his essay soon revealed whether he was a man of observation, or a blind reader of technical journals.

It is obvious by comparing the above syllabus with the one in use to-day, that the Institution has extended its views considerably since the early days. They were reluctant to withdraw the psychology item, but the technical representatives, whilst admitting the value of this subject, pointed out that, in the first place, it was difficult to inoculate young people with psychology, in the second place, the number of teachers who were competent to teach this involved subject was almost negligible. Later on, economics suffered a similar fate, and it is worthy of note that, at about the same

time, the Institution of Mechanical Engineers substituted "Works Organisation and Management" for "Economics," in their Associate Membership examination. At the same time the examination was stiffened up. Instead of one day two days became necessary.

At the present time, then, the requirements of the Institution, from the point of view of technical knowledge, are set out as follows: One optional paper selected from the following: (*a*) Construction of machine tools, and jig and tool design; (*b*) Physical Metallurgy and treatment of metals; (*c*) The Application of Electricity to Production.

In addition, the following compulsory subjects are included: Workshop practice and processes, Factory Organisation, Planning Storekeeping, and Costing.

Although the fatal word "Economics" has been eliminated, under the heading of "Factory Organisation" and "Planning, Storekeeping, and Costing" the best elements of the original syllabus have been preserved.

The weakness of examinations as a whole was revealed in the second examination that was held. A clerk, who had no factory experience outside the stores office, passed the whole of the subjects with flying colours. In the eyes of the Institution, however, it is necessary that a prospective graduate shall have workshop experience, and, further, that he shall have studied at a recognised college. In regard to the latter, the Examination Board, with the consent of the Council, are now exempting students of approved colleges, after they have completed their full course in engineering production.

The Opinion of Educational Authorities.

I wrote to over 30 educational institutions, and, either my letter was ambiguous or they misread my meaning, for, in very few cases did I receive a real expression of opinion from our friends on the technical side. Maybe, perhaps, one or two of them scented a trap, for they replied that it was difficult to put their ideas in a few words, and would much prefer to discuss the matter personally. In general—*works training*, prior to entering the University or the technical college, is advocated.

Below are a few extracts, which are deemed worthy of comment:

(*a*) Recommends co-operation between the local school and the employer, and submits a syllabus that would cover similar ground to that in our examination.

(*b*) Considers that secondary or public scoolboy should be selected, and that they should work on common ground with students who are taking the ordinary National Certificate.